USER MANUAL

MODEL 853-9

TWO-WIRE
ppm D.O. TRANSMITTER
EXPLOSION-PROOF, BARREL HOUSING

um-853-9-210

IC CONTROLS

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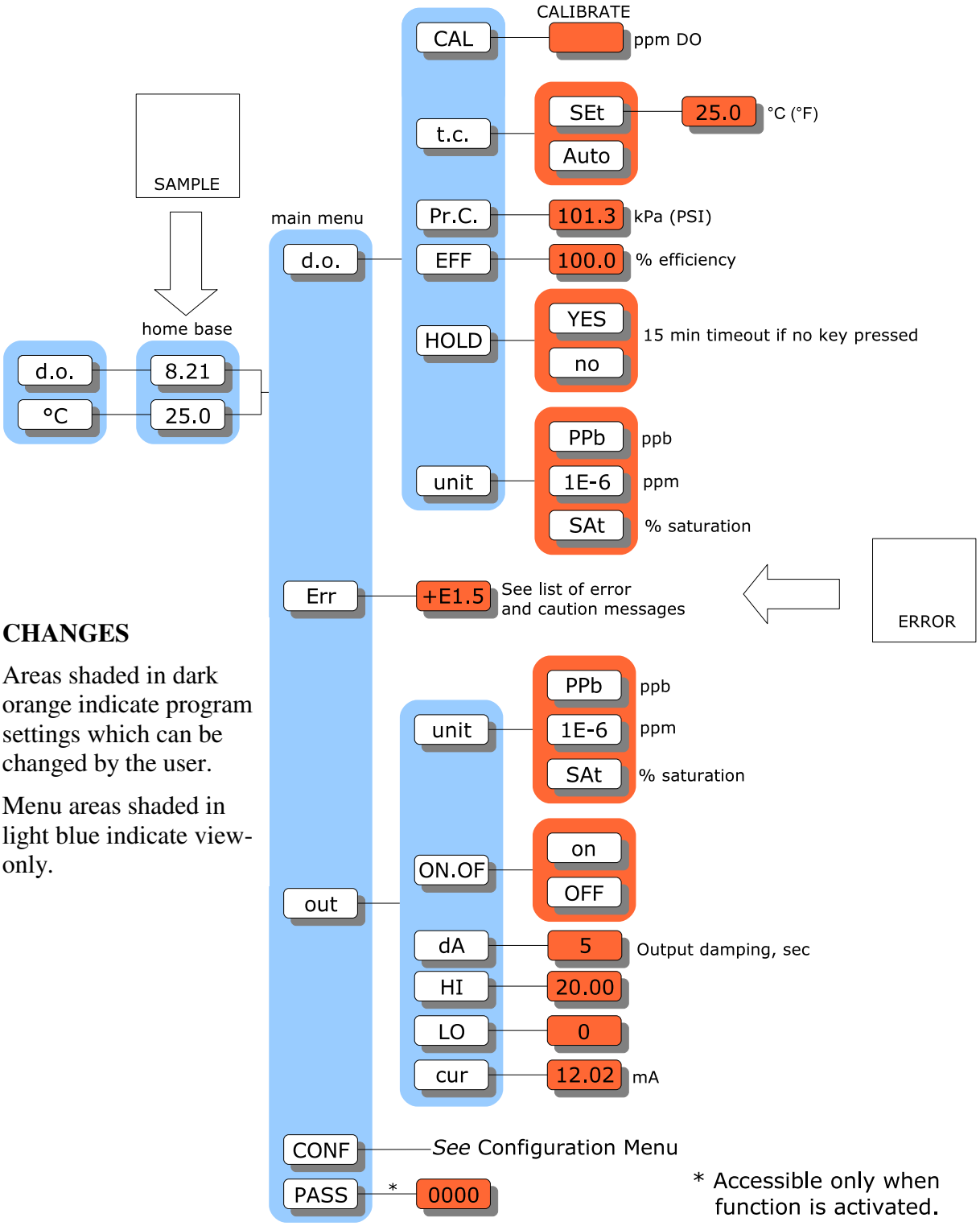
853-9 MENUS



CHANGES

Areas shaded in dark orange indicate program settings which can be changed by the user.

Menu areas shaded in light blue indicate view-only.

Illustration 1: Menu layout

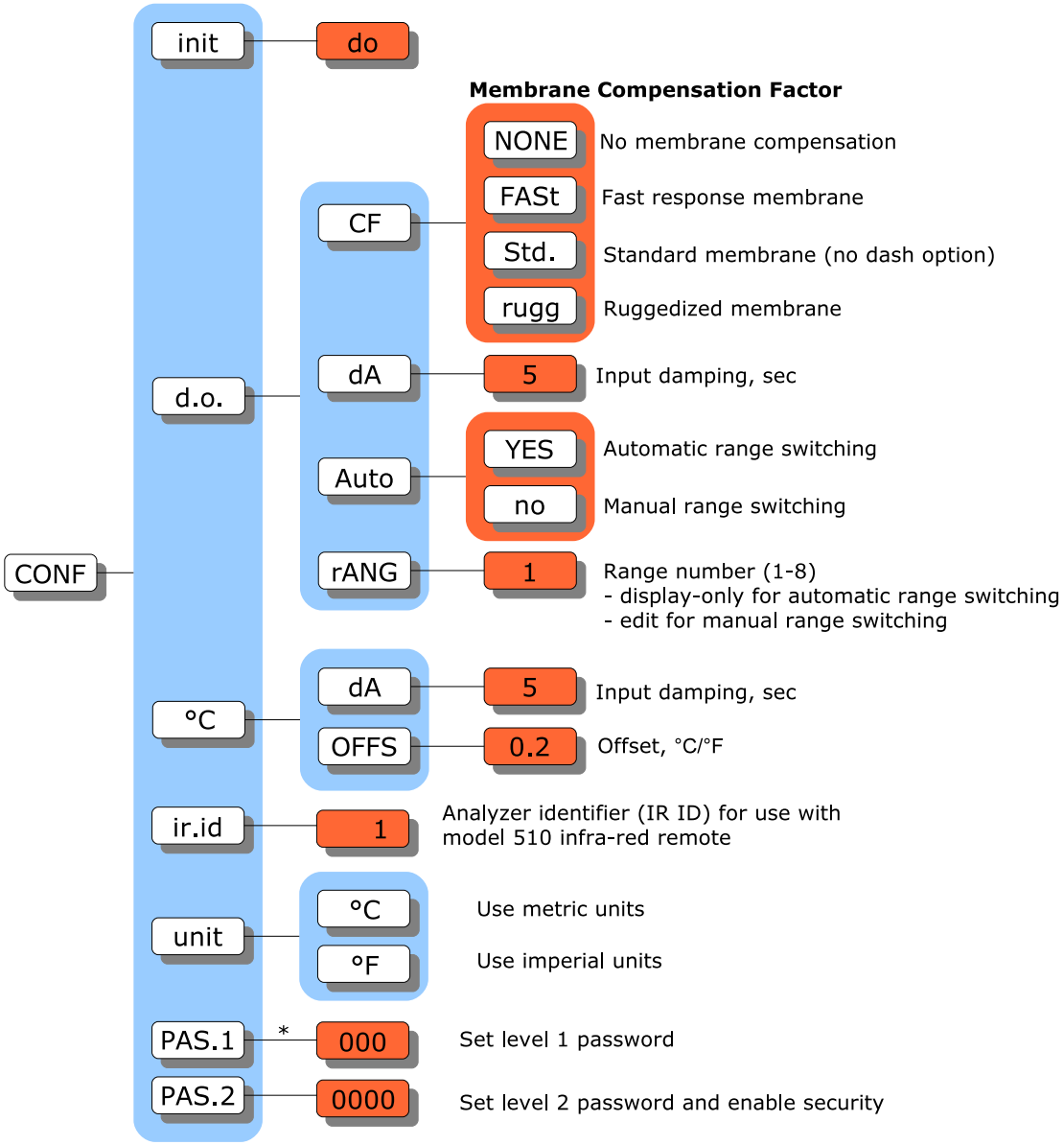


Illustration 2: Configuration menu

INTRODUCTION

The model 853-9 as shipped from the factory is calibrated and should not require recalibration other than a minor software zero and span adjustment to match your receiver or recorder. As received, the transmitter's span has been calibrated to 0 ppm to 20 ppm which covers most common processes.

General

The 853-9 is one of a series of explosion proof, barrel housing type, two-wire transmitters. It is considered to be a two-wire device because both the power and signal use the same two wires. In the case of dissolved oxygen, a D.O. signal corresponding to the actual dissolved oxygen is converted to a 4 mA to 20 mA signal which is carried along the same two wires as the 24 VDC power used to power the device.

Features

1) **Instrument housing** which is:

   —Class 1, Groups B, C & D; Class 2, Groups E, F & G rated.
   —NEMA 4, Watertight, dustite rated.
   —NEMA 7, Hazardous; for indoor use Class 1, Groups A, B, C & D as defined by NEC.
   —FM Approved.
   —CSA Certified.
   —Cenelec Certified, EExd IIC, IP66.

2) Ability to mount at any 90 degree angle from normal.

3) Operation via infra-red remote control.

4) Automatic temperature compensation.

5) Standard ¾ inch NPT feed-through conduit provides ample space for wires to pass.

6) Steering diode protects 4 mA to 20 mA power from damaging electronics.

Note: Refer to *Appendix C* for complete transmitter specifications.

INSTALLATION

Transmitter Mounting

The sensor is typically supplied with a 1.5 m (5 foot) lead as standard. The transmitter should be kept within this distance. The transmitter should be positioned to allow the sensor, while connected, to be removed and the electrode tip placed in a beaker on the floor for cleaning or calibration. Assume the safest place for the beaker is on the floor the service person stands on. The electrical connection is on the left side, and the electrode connection is on the right side. Horizontal separation between rows of transmitters should allow for electrode leads, which need periodic replacement, and the electrical connections. IC Controls recommends 10 cm (4 in) minimum separation between rows/columns.

As standard, the 853-9 comes with a 5 cm (2 inch) pipe mounting kit; refer to drawing D4000076 for enclosure mounting dimensions.

Field Mounting Orientation

The 853-9 can be mounted in any 90 degree increment from standard. Refer to drawing D4000074.

Use the procedure below to select the desired mounting orientation.

1. Calibrate the transmitter to the desired range in the instrument shop.
2. Take the transmitter to field location to check orientation.
3. If the transmitter is in the correct orientation go to step 10.
4. If the transmitter is not in the standard orientation, return to instrument shop.
5. Loosen front cover tamper set screws and remove front cover.
6. Undo the four Phillips screws and remove front panel to display PCB board. Refer to drawing D4000075.
7. Undo the four ¼ inch diameter ⅝ inch long hex standoffs and remove main PCB.
8. Orient main PCB in desired direction keeping in mind eight-position header is the top.
9. Refasten standoffs following steps 6 and 7 in reverse order.
10. Mount transmitter with the hardware provided; pipe mount only.

Transmitter Wiring

The transmitter requires 24 VDC power via the 4 mA to 20 mA output, TB200 terminals 1 and 2. For stable operation, the microprocessor needs a good ground. A good ground connection can typically be made using a shielded 4 mA to 20 mA wire connected to ground in the transmitter and to a local earth rod, or earth at the 24 VDC power supply. The transmitter requires 24 VDC to operate properly. The "on board" regulation allows the supply to vary to any level between 16 VDC to 40 VDC without affecting the transmitted signal.

To hook up power to the transmitter, perform the following wiring procedure.

1. Ensure 24 VDC power is not hooked up at control room or DCS end.
2. Unscrew tamper-resistant set screw and remove rear cover.
3. Using 18AWG to 22 AWG wire, hook up 4 mA to 20 mA power connections to TB200, **+ 24 VDC** and **RETURN** terminals as shown in illustration 3.

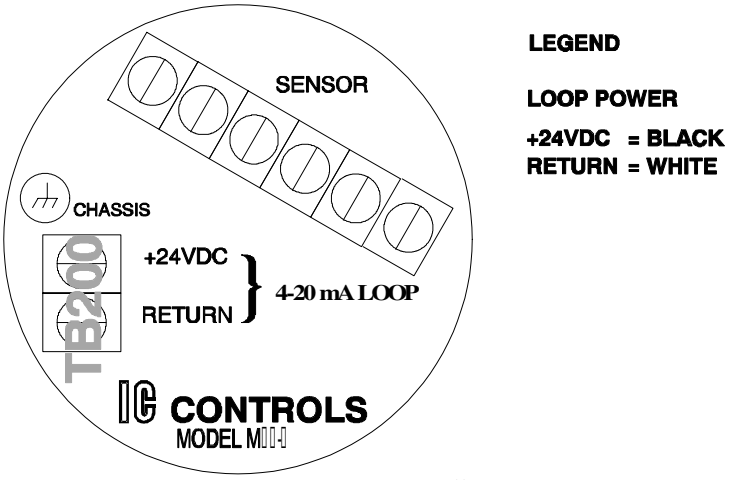


Illustration 3: Power Wiring

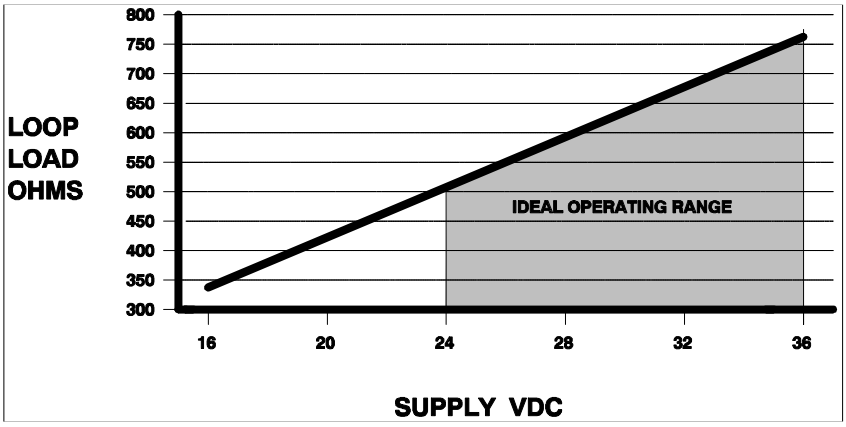


Illustration 4: Maximum loop resistance

Hazardous Location Information

Installation should be performed in compliance with all applicable local electrical safety codes. The 853-9 uses 24 VDC supply, generally considered low hazard in general purpose applications. However, IC Controls recommends that the following safety practices be followed.

- Conduit seals should be installed within 46 cm (18 in) of the enclosure.
- Ensure all covers are on and firmly in place before power is applied.
- Set tamper resistant set screws.
- Disconnect power before opening covers.

NOTE: *Dissolved oxygen sensors and RTD temperature compensators are passive and meet the intrinsic safe definition of a simple device. A simple device is either a passive device such as an RTD or a component with such a small signal that a spark is not possible. Simple devices do not require certification as they are intrinsically safe by nature.*

Sensor Mounting

It is recommended that the sensor be located as near as possible to the D.O. transmitter to minimize any effects of ambient electrical noise interference. Flow and insertion sensors can be in any orientation but should be mounted tip down at an angle anywhere from 15 degrees above horizontal to vertical. 15 degrees above horizontal is best because air bubbles will rise to the top and debris will sink, both bypassing the sensor.

Submersion sensors should not be mounted where a lot of air bubbles rise in the tank, they will cause spikes in the D.O. readout.

Sensor Wiring

Ensure 24 VDC power is disconnected at supply end.

The sensor is connected to TB100 which is a six-place terminal block as follows:

CLEAR (Shield) wire = REF
ORANGE wire = DO+
RED wire = T+
WHITE wire = T-

Refer to drawing D5020256 for the wiring diagram.

Sensor Preparation For Use

1. Slowly and carefully remove the lower (storage) plastic cap. Rinse the exposed dissolved oxygen membrane tip with tap water.
2. For first time use, or after long term storage, immerse the lower end of the sensor in tap water for 30 minutes. This wets the dissolved oxygen membrane and prepares it for stable readings with test solutions.

NOTE: *IC Controls sensors are shipped dry. These electrodes are often ready for use immediately with typical accuracy of ± 10% dissolved oxygen without calibration. For optimal performance, it is recommended that prior to calibration the sensor soak in zero D.O. standard, P/N A1100193, followed by a soak in tap water to achieve best accuracy.*

Instrument Shop Test Startup

1. Apply 24 VDC power to the transmitter.
2. Hook up the sensor via TB100 and remove the orange protective cap from sensor.
3. Place the sensor in air.
4. The 853-9 D.O. transmitter should come up reading 8.00 ppm ± 1.00 ppm.
5. Perform a zero calibration for a reading of 0.00 ppm ± 0.20 ppm by placing the sensor in zero D.O. standard, P/N A1100193; allow 30 minutes warm-up time for the electronics to stabilize.
6. Perform a span calibration by placing the sensor in air. The display should read approximately 8.50 ppm.
7. To check for general performance, place the sensor in tap water. The display should read approximately 4.00 ppm ± 2.00 ppm (tap water D.O. varies with the local source).
8. Before putting the transmitter into operation, verify the settings to ensure that they agree with the intended setup.
   For the 4 mA to 20 mA output, set high limit and low limit.
9. Set preference for temperature, °C or °F, in [CONF] [unit].
10. Set desired input signal damping if known; default is 5 seconds.
11. The transmitter is now ready for field installation.

NOTICE OF COMPLIANCE

US

This meter may generate radio frequency energy and if not installed and used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. It has been type-tested and found to comply with the limits for a Class A computing device in accordance with specifications in Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in an industrial installation. However, there is no guarantee that interference will not occur in a particular installation. If the meter does cause interference to radio or television reception, which can be determined by turning the unit off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

* Reorient the receiving antenna
* Relocate the meter with respect to the receiver
* Move the meter away from the receiver
* Plug the meter into a different outlet so that the meter and receiver are on different branch circuits

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful: *How to Identify and Resolve Radio-TV Interference Problems*. This booklet is available from the U.S. Government Printing Office, Washington, D.C., 20402. Stock No. 004-000-00345-4.

CANADA

This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulations of the Canadian Department of Communications.

Le present appareil numérique n' émet pas de bruits radioélectriques depassant les limites applicables aux appareils numériques (de la class A) prescrites dans le Règlement sur le brouillage radioélectrique édicté par le ministère des Communications du Canada.

STARTUP

If the transmitter is new and has not been installed, then follow the procedures described in the *Installation* section before mounting. If the transmitter has been previously installed, all that is required is to attach the electrode to the transmitter and then turn on the power.

The transmitter will go through its automatic startup procedure any time power to the transmitter is lost for more than a few seconds. The startup procedure will initialize the transmitter program, perform error checks, scroll the unique 10 digit serial number of the unit and then proceed to display the dissolved oxygen reading and function normally.

All program settings, calibration settings, and default values will have been retained by the transmitter.

Transmitter Startup Tests

The startup procedure will begin by scrolling a flashing [IC CONTROLS] across the display while performing memory tests. The transmitter will proceed to display, in sequence, the transmitter model number, in this case [853-9], any software option numbers, and the program version number, e.g.[2.10]. The program then proceeds to perform display tests; each of the implemented display segments will light up in turn. If the transmitter passes all the startup tests then the hardware is functioning properly and the transmitter will proceed to display parts per million dissolved oxygen, or error messages, if detected.

If the transmitter displays +Err or -Err, this indicates that the input is off-scale. An off-scale error can indicate that the electrode is not in solution, is off-scale, or is not connected properly. If the display periodically flashes [Err], go to the error display section; press *ERROR* key or select [Err] from the main menu to view the error codes detected by the transmitter.

Calibration Settings

If the transmitter was calibrated previously, then the transmitter will use the calibration settings from the last successful calibration, otherwise default settings are used. Error and caution messages generated during the last calibration will remain in effect. IC Controls recommends a complete calibration after initial startup. Refer to the *Calibration* section for calibration procedure.

Transmitter settings and parameters can be viewed and/or changed at any time. Refer to the menu on page 3; the areas shaded in dark orange indicate program settings.

Serial Number Display

The transmitter's unique serial number can be viewed at any time. Press the *DIAG* key or the *SAMPLE* key 4 times to call up the startup display routine above. This does not change any customer settings. The serial number is the 10 digit number that scrolls across the screen.

EASY MENU

The layout of the program is shown in the menu found on page 3. The menu can be used as a quick reference guide to all of the transmitter functions.

Remembers Where You Were

The transmitter remembers where *home base* is, which areas of the menu were used last, and it will loop around the columns in the menu. The menu can be explored using the arrow keys to find any parameter. Pressing the *SAMPLE* key will return display to *home base*. Pressing the → key will return the user to exactly the area of the menu most recently accessed.

Home Base — Press SAMPLE

The *SAMPLE* key's function is to give the user a known starting point displaying the *home sample* or *home input*. The *SAMPLE* key is usable from anywhere in the menu. The program will safely abort whatever it was doing at the time and return to displaying the dissolved oxygen reading.

The dissolved oxygen display is the *home base* display for the transmitter. The transmitter's two inputs, D.O. and temperature, are arranged underneath each other at the left-hand side of the menu. Use the ↑ or ↓ key to display each of the readings in turn.

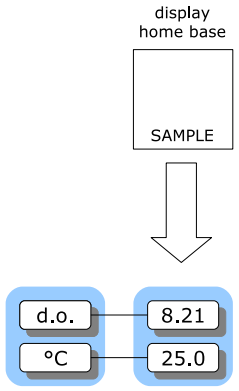


Illustration 5: Home base

Features

1. The transmitter has a built-in timer which returns the program to displaying the home base if no key has been pressed for 15 minutes. This time-out has the same effect as pressing the *SAMPLE* key.
2. When in doubt as to what the transmitter is displaying, pressing the *SAMPLE* key will ensure it is displaying dissolved oxygen. Pressing the ← key will show the sample parameter being displayed. Pressing the → key will return to displaying the sample reading.
3. If security has been enabled, the timeout will change the access level back to 0 or 1 automatically, which gives the user read-only access. The user will have to enter an appropriate password to go to a higher access level.

Arrow Keys

The arrow keys on the keypad are used to move around in the menu. The same keys can have other functions as well, refer to *Edit Mode*.

Example:
Press *SAMPLE* to get to *home base*. Press the → key. One of the prompts in the *main menu* column starting with [d.o.] will be displayed - refer to illustration 6. Use the ↑ key to display the prompt above; at the top, the program will loop around. Press the ↑ key until [CONF] is displayed. Press the *SAMPLE* key to return to the dissolved oxygen display. Press the → key again and [CONF] will be displayed again.

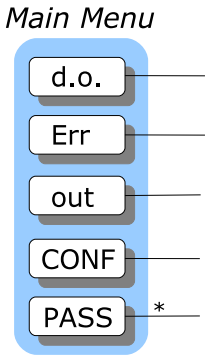


Illustration 6: Main menu

DIAG and ERROR Keys

The DIAG and ERROR keys are used to access the diagnostic and error or alarm conditions in the transmitter. Refer to the *Caution and Error Messages* section for a description of these key functions.

ENTER Key

The *ENTER* key is used to access the ability to change values or edit settings.

EDIT MODE

Edit mode is used to change a numeric value or to select between different options. The values and settings which can be edited are identified by the darker shading in the menus. Any frame which has a white background cannot be modified by going into edit mode but can be viewed.

Selecting a Setting

Examples of selecting a value are on/off settings and switching between different units (eg. metric or imperial). Editing a value is like picking an option from a list; only one item on the list can be viewed at a time.

Example: Turning output off.

From the menu, select [out] [ON.OF]. The transmitter will now display either [ON] or [OFF], which are the two choices. To change the setting, press *ENTER* to go into edit mode. The display will start blinking. Use the ↑ or ↓ keys to switch between the possible options, which in this case are [ON] and [OFF]. When [OFF] is displayed, press *ENTER* again to accept the new setting and leave edit mode.

Editing a Numeric Value

Numeric values such as input damping are adjusted by going into edit mode and then adjusting each digit until the new value is displayed. Use the ← and → keys to move between digits and use the ↑ and ↓ keys to adjust each digit.

When *ENTER* is pressed to go into edit mode, two things will happen. First, the last digit will start blinking to show that this digit can be changed. Second, any blank spaces will change to zeros and a plus or minus sign will appear. Now each digit can be accessed. Change between positive and negative numbers by switching between plus and minus sign using the ↑ or ↓ key when the +/- segment is blinking.

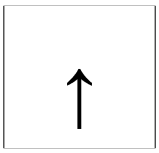
Press *ENTER* again to leave edit mode. Before the new value is changed, the transmitter will check the new value to make sure that it is within range. If the new value is lower than the lowest value allowed for that frame then the transmitter will use the lowest allowable value instead of the new value entered. Likewise, if the new value entered is higher than allowable then the highest allowable value is used instead. The transmitter will display whatever value it has stored in memory.

Example: Change the low from 0 ppm to 2 ppm.

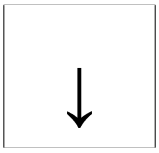
From the menu, select [out] [LO]. The current set-point (e.g. [0.00]) will be displayed. Press *ENTER* to select edit mode. The display will change to [+ 00.00] and the last digit will start blinking. Press ← twice to move left two digits. The third digit from the end will now be blinking. Press the ↑ key to change the '0' to '2'. Press *ENTER* again and the display will change from [+00.00] to [+02.00] indicating that the new value has been stored in memory.
The 4 mA to 20 mA low set-point has now been changed from 0.00 ppm to 2.00 ppm.
Press the ← key to display [LO], [out] etc.

Key Functions in Edit Mode

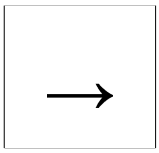
Enters edit mode. The entire display or a single digit will blink to indicate that the transmitter is in edit mode. Press the *ENTER* key again to leave edit mode and accept the new value.



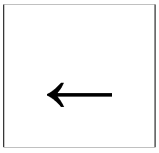
Adjusts blinking digit upward or selects the previous item from the list. If a '9' is displayed then the digit will loop around to show '0'.



Adjusts blinking digit downward or selects the next item from the list. If a '0' is displayed then the digit will loop around to show '9'.



Numeric values only: move right one digit. If blinking is already at last digit, display will loop to the +/- sign on the left.



Numeric values: move left one digit. If blinking is at the +/- sign then blinking goes to the last character.
Settings: restore the initial value if it was changed. Otherwise leave edit mode without doing anything.

Illustration 7: Infra-red remote keys used in edit mode

510 REMOTE KEYPAD

The model 510 remote keypad is required to operate the explosion proof versions of the 53 series. The 510 is a battery powered infra-red light based remote control similar to a TV remote. In addition, the 510 has components that make it intrinsically safe.

The 510 operates through the front viewing window of the 853-9 case. It allows a fully functional modern transmitter with multiple external adjustments and access to microprocessor intelligence, without the cost and risks of multiple ports into the explosion proof enclosure.

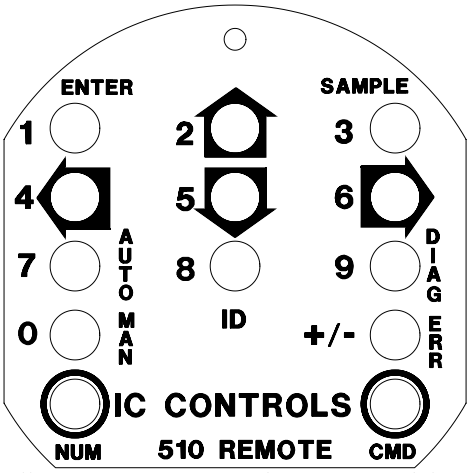


Illustration 8: Infra-red Remote, model 510

Remote Keypad Operation

The 510 remote operates exactly like a front panel mounted keypad, with the exception that you have to point the IR diode at the front of the transmitter. The keys are laid out in the same pattern as a standard IC Controls front panel keypad, with their functions identified in orange. By default, the transmitter recognizes all these commands, and is said to be in CMD (command) mode.

The 510 remote has extra keys for AUTO, MAN (manual), DIAG (diagnostics), ERR (error), ID (identity), NUM (black numbers), and CMD (orange commands). These keys allow optional functions available with particular IC Controls products.

ID Key

The ID key is used when an array of transmitters are grouped close together and it is possible for more than one transmitter to "see" and "respond to" the same IR remote signal. IC Controls ships the unit with ID equal to 01 by default; it can be field changed to any two digit number up to 99. Where an array is planned it is easiest to preset the ID to a unique number before installation. However, by stepping *close enough* that *only one unit* sees the signal the ID can be changed in the installation. Unit ID's can be changed in the [CONF] menu under [ir.id].

Selecting the desired unit using ID

1. Press the 510 "ID" key once. All units that can "see" the signal will display their ID for 5 seconds.
   Example: the transmitter responds with [id.12].
2. Within the 5 seconds, type the ID code of the transmitter you want using the black numbers on the 510.
   Example: All transmitters respond with [id.1], then [id.12] as the digits are pressed.
3. Operate the identified (active) unit as normal. All the other inactive units will ignore the 510 signals, except for the ID key.

4. To activate a different transmitter, repeat steps 1 and 2.

NUM Key

The ID key is useful for entering numbers directly, rather than scrolling with the arrow keys. The unit responds to the NUM key with [—N—] and to CMD with [—C—]. Numbers update in the natural left to right sequence.

Entering numbers using NUM

1. Proceed to the value to be edited, then press *ENTER*.
2. With the display flashing (edit mode), press *NUM*, then the desired value.
3. With the correct number flashing, press *CMD* and then *ENTER*; the display will stop flashing and the edited number will be installed.

SECURITY

The 853-9 has a built-in password protection system. This security system is disabled by default and does not need to be enabled if no password protection is necessary. If the password protection system is not enabled, then the user will have unrestricted access to all transmitter settings available through the menu as described in this manual.

Having security disabled provides the same access to the program as being at access-level 2 at all times.

With security enabled, anyone can view settings anywhere in the program. When proper access rights are not warranted, the program will display [PASS] for 2 seconds, indicating that a proper password must be entered before being allowed to proceed.

Access-Level	***Description***
0	View-only access to all settings
1	Access to all settings except for configuration menu. **Usage:** Operator access. No changes can be made to configuration and passwords cannot be changed.
2	Access to all settings. This allows the same access to program as when password security is not enabled. **Usage:** Installation, management.

Table 1: Security access levels

Enabling Password Security

When security is disabled both password 1 and password 2 are set to "0000." Security is enabled by setting password 2 to a non-zero value.

Select [CONF] [PAS.2] from the menu. The transmitter will display [0000]. Use the arrow keys to change the display to the desired password for level 2. Pressing *SAMPLE* at any time will safely cancel password entry. Press *ENTER* to enter the password into memory and to enable password security. The transmitter program automatically returns to the configuration menu.

With only password 2 set to a non-zero value: level 2 access is required to make changes in the configuration menu but all other settings are unprotected. Effectively, the user will always have at least level 1 access.

At this point password 1 is still "000." You may optionally enable operator access control or level 1 security by changing the level 1 password from "000" to a non-zero value. Change the password by selecting [CONF] [PAS.1] from the menu, then entering an appropriate 3-digit password.

Write down the passwords set and store them in a secure place; once a password has been set, there is no way to redisplay it. Since passwords are set in the configuration menu, level 2 access is required to change either password. If the level 2 password has been forgotten, there is no simple way to regain access to the transmitter. Contact the factory if you find yourself locked out of the transmitter.

Disabling Password Security

Password security can be disabled by setting the level 2 password to “0000.” In order to change the password, level 2 access is required to enter the program.

Select [CONF] [PAS.2] from the menu, then press *ENTER* when the program displays [0000]. Both passwords 1 and 2 are set to “0000" and security is now disabled. The main menu will be changed to exclude the [PASS] frame, and the configuration menu will no longer have the [PAS.1] frame.

Entering a Password

With security enabled, select [PASS] from the main menu. The transmitter will display [0000]. Using the arrow keys, edit to display level 1 or level 2 password, then press *ENTER*. The program will display [good], followed by the access level before returning to the main menu. If an incorrect password was entered, the program displays [bAd] instead. Refer to illustration 9 to see how the program validates a password.

Level 1 or level 2 access is now acquired for as long as the transmitter is being operated. The access level will automatically be restored to level 0 after no key has been pressed for 15 minutes. This 15-minute time-out will also redisplay the main sample.

It is good practice to return the transmitter to level 0 access (or level 1 access if password 1 is set to “000”) once the access-level user has finished using the transmitter. This is accomplished by selecting [PASS] from the main menu, then pressing *ENTER* with [0000] displayed.

Password Example — a Quick Tour

With security disabled, select [CONF] [PAS.2] from the menu. Set the level 2 password to “0002". Select [CONF] [PAS.1] from the menu. Set the level 1 password to ”001." Security is now enabled.

Select [PASS] from the main menu. Press *ENTER* with [0000] displayed. The transmitter will display [ACC.0] to indicate we are now at access level 0.

Try changing the output low setting. Select [out] [LO] from the menu. The current value will be displayed. Press *ENTER* to go into edit mode. The transmitter will display [PASS] for 2 seconds because a password needs to be entered first. Level 1 security is needed to change this setting.

Select [PASS] from the main menu again. Change the displayed value to [0001], which is the level 1 password and press *ENTER*. The transmitter will display [good], followed by [ACC.1], indicating that the password is valid and that level 1 access has been achieved.

Try changing the output low setting again. This time, edit mode can be attained unhindered.

Select [PASS] from the main menu again. Enter the level 2 password, which is “0002.” Change the level 2 password to “0000” in order to disable password security. Password 2 is found in the configuration menu and therefore requires level 2 access before it can be accessed. Select [CONF] [PAS.2] from the menu. Press *ENTER* with [0000] displayed. Both passwords are set to “0000” again and password security is disabled.

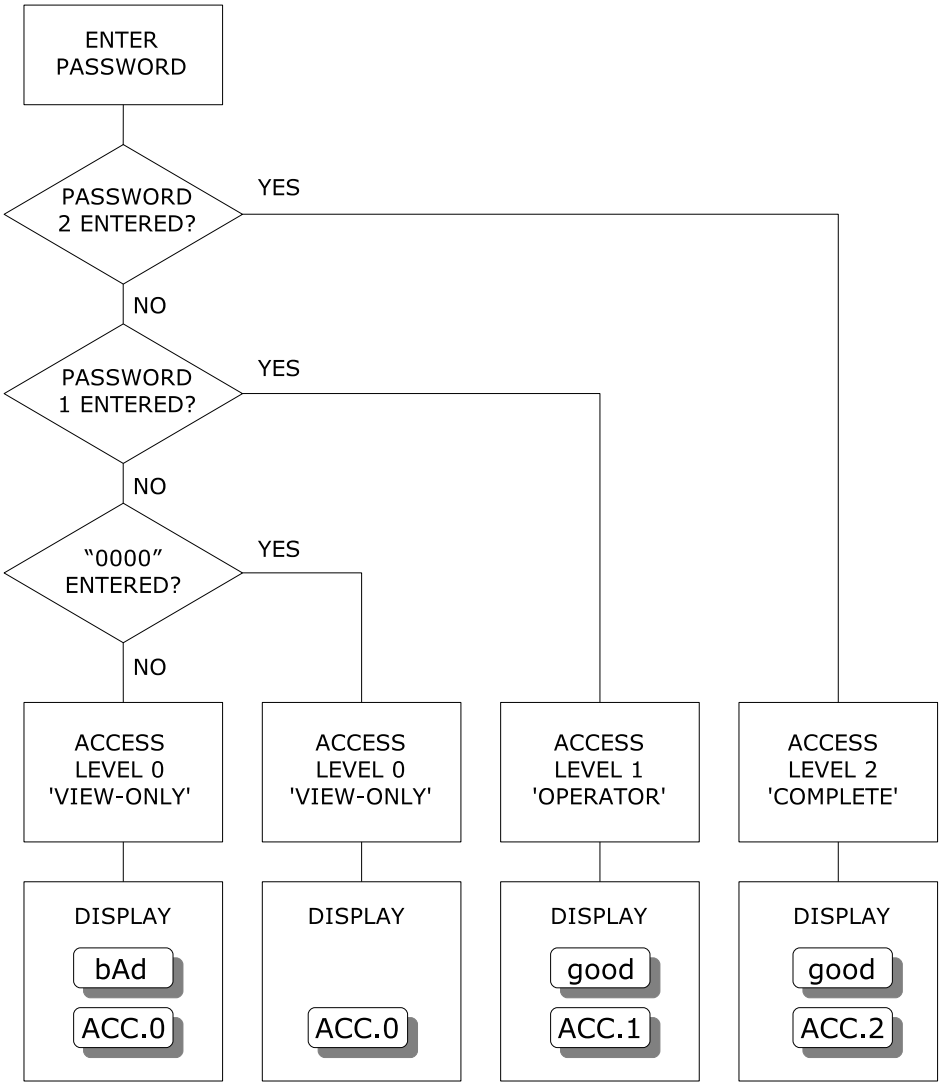


Illustration 9: Password logic

D.O. MEASUREMENT

Introduction

Dissolved oxygen is a measure of the amount of oxygen, usually thought of as a gas, that is dissolved in a liquid such as water. Oxygen is essential to life, even for fish and other aquatic forms, plus is the most common element found taking part in corrosion reactions.

Mechanically hard and porous metal oxide deposits have little strength and form rapidly in the presence of water and oxygen. Rapid corrosion will occur inside an industrial utility boiler system unless dissolved oxygen can be virtually eliminated. Corrosion results in expensive repairs or equipment failures and subsequent replacement.

Galvanic Measuring Cell

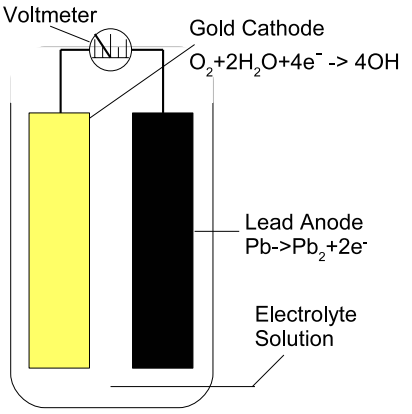


Illustration 10: Basic galvanic cell

The dissolved oxygen measuring sensor used with the 853-9 is an electrochemical cell similar to a battery that produces a current when oxygen is present. By using carefully selected electrodes, in contact with an appropriate electrolyte, a chemical reaction occurs that uses electrons gained from oxygen molecules to produce a galvanic current directly proportional to the concentration of oxygen present. Illustration 10 shows how such an electrode system works in a simple laboratory test. Illustration 11 shows how these scientific principles can be implemented into a working dissolved oxygen electrode. Also, unlike an electrolytic cell in which a flow of current produces the chemical reaction, there is no zero-current as galvanic current is naturally zero when zero oxygen is present.

The D.O. sensor uses a galvanic cell separated from the sample by an oxygen permeable PTFE (teflon) membrane. The cell has a gold cathode in close contact with the PTFE membrane where oxygen (O_2) gains electrons (is reduced) to become hydroxyl ions (OH^-), and a lead (Pb) anode that produces a fixed potential regardless of oxygen concentration, to complete the circuit.

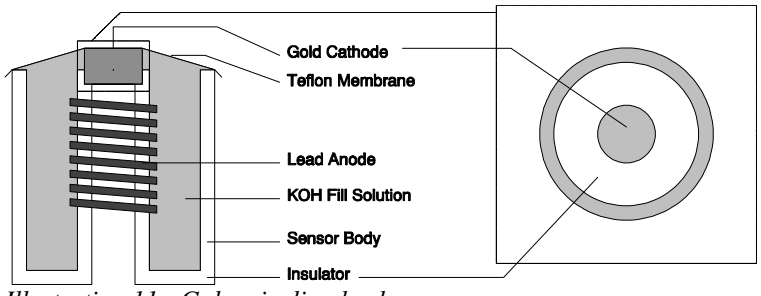


Illustration 11: Galvanic dissolved oxygen sensor

The chemical reactions within the cell are:

At the cathode:

$$O_2+2H_2O+4e^{-1}=4OH^{-1}$$

At the anode:

$$2Pb=2Pb_2+4e^{-1}$$

Overall:

$$O_2+2H_2O+2Pb=2Pb_2OH$$

Display Units

By default the 853-9 transmitter will come up reading parts per million dissolved oxygen. The unit setting allows the transmitter to display the dissolved oxygen reading using either ppm (parts per million), ppb (parts per billion), or percent saturation units.

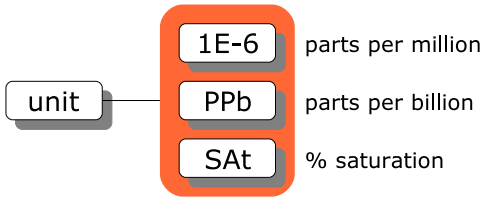


Illustration 12: Display units for dissolved oxygen input

The terms "parts per million" and "parts per billion" are not part of the International System of Units (SI). These units are in common usage in many parts of the world. In the United States the translation to SI units for concentrations in liquid is as follows:

parts per thousand: $1\ ppt = 1\ g/L$

parts per million: $1\ ppm = 1\ mg/L$

parts per billion: $1\ ppb = 1\ \mu g/L$

A problem with the use of these units is that their meaning is language-dependent. In the U.S., a billion refers to a thousand million, whereas in Britain a billion is typically understood to mean a million million. For scientific purposes the meaning of a "billion" is ambiguous. Additionally, the term "ppt" could equally well refer to "parts per thousand" or "parts per trillion". Add the language ambiguity to the 'thousand vs. trillion' ambiguity and "ppt" can mean any of "parts per thousand", "parts per 10^{12}", or "parts per 10^{18}". This manual uses the term "billion" to mean a thousand million, so that ppb denotes "parts per 10^{9}".

The percent saturation unit displayable by the transmitter displays the calculated percent of maximum concentration of dissolved oxygen at the current temperature and pressure. For example, at 25 °C (77 °F) and 101.3 kPa (1 atmosphere, 14.69 psi) the maximum amount of oxygen that can be dissolved in water is 8.24 ppm. If at this temperature and pressure the transmitter is measuring 2.0 ppm, the percent saturation would be:

$$\frac{2.00\ ppm}{8.24\ ppm} \times 100\,\% = 24.\,\%$$

Switch between display units by changing the setting in [d.o.] [unit]. The options are [1E-6] for ppm (1E-6 is scientific notation for millionth), [PPb] for ppb (equivalent to 1E-9), and [SAt] for percent of saturation.

The conversion between ppm and ppb is as follows:

$$1\ ppm = 1{,}000\ ppb$$

$$1\ ppb = \frac{1}{1000}\ ppm$$

The conversion between ppm or ppb to percent saturation is somewhat more complicated because this conversion is not a simple multiplication factor, but depends on the temperature and pressure of the solution. Illustration 13 shows the D.O. concentration at various temperatures and pressures. Both the temperature and the atmospheric pressure need to be known in order to accurately calculate the percent saturation of the solution.

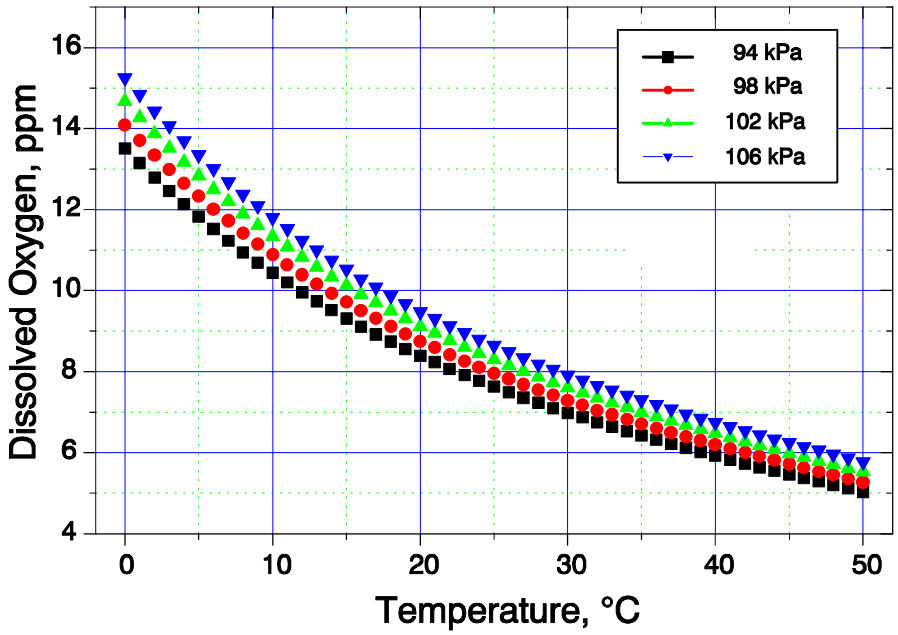


Illustration 13: ppm D.O. values at various temperatures and pressures

D.O. CALIBRATION

Saturated Air Calibration Technique

At any given temperature and barometric pressure, the partial pressure of oxygen in water-saturated air is exactly the same as it is in air-saturated water. Thus, a sensor can be calibrated in water-saturated air, using the 20.9% oxygen available in air as the full-scale standard, and it will correctly read dissolved oxygen in water samples. Both temperature and barometric pressure affect the partial pressure of oxygen in air-saturated with water vapor.

The 853-9 has a microprocessor memory programmed with all the values, plus automatic temperature compensation, so it can automatically obtain the correct data, look up the dissolved oxygen table, compute the correct gain, and calibrate the transmitter.

The operator need only remove the cell and suspend it over a beaker of tap water. This calibration technique will give a 100% saturation reading for the temperature and pressure which the 853-9 will display as ppm dissolved oxygen (actual dissolved oxygen table values are listed in *Appendix D*).

To calibrate the D.O. sensor, suspend the probe above water in a beaker and let the transmitter auto calibrate; refer to illustration 14.

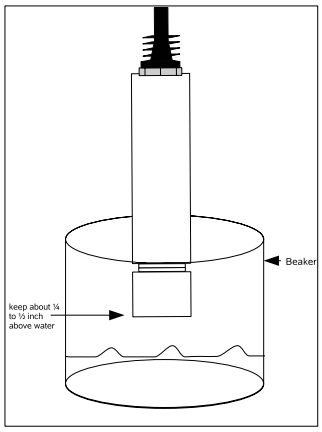


Illustration 14: Calibration setup

Zero Test Technique

The best way to zero check at the point of use, is to use a zero oxygen standard (sodium sulfite oxygen scavenger with a cobalt chloride catalyst) available from IC Controls as P/N A1100193 in a 500 mL bottle, or as a 6-pack as P/N A1100193-6P.

Caution: If zero standard gets on hands, wash with running water.

Preparation of Zero Oxygen Standard:

To 1 liter of distilled water add 20 grams of Na_2SO_3 and 10 milligrams of Co_2Cl_2 and mix thoroughly. Make sure that the zero standard is used within 8 hours because the oxygen scavenger will be used up quickly with exposure to air.

Submerge the D.O. sensor in a deep beaker so that it is 2 inches to 3 inches below the surface of the liquid; refer to illustration 15. Provide slow gentle movement to ensure the oxygen present is consumed. The D.O. sensor should rapidly fall to 0.1 ppm to 0.2 ppm levels, confirming operation of the sensor.

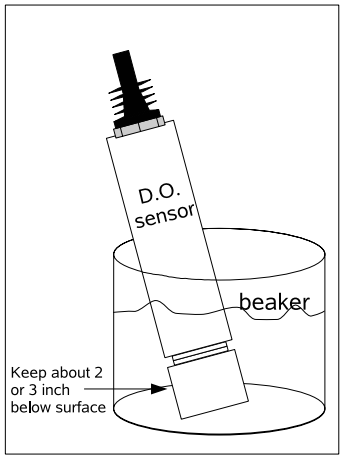


Illustration 15: Zero test setup

Temperature Compensation

Almost all industrial applications encounter fluctuating temperature and need rapidly responding automatic compensation. IC Controls dissolved oxygen sensors have a temperature compensator (TC) built into the D.O. sensor. The TC is wired to the transmitter allowing the 853-9 to provide digital temperature compensation.

If no automatic temperature compensator is available or needed, manual temperature compensation can be used. If the temperature of the sample is constant, set the manual TC temperature to the process temperature. If the process temperature varies or is unknown, a default temperature of 25 °C or 77 °F is normally used.

Selecting Manual Temperature Compensation

To see the current temperature compensation method used by the 853-9 transmitter during calibration and for calculation of percent saturation, select [d.o.] [t.c.] from the menu; refer to illustration 16.

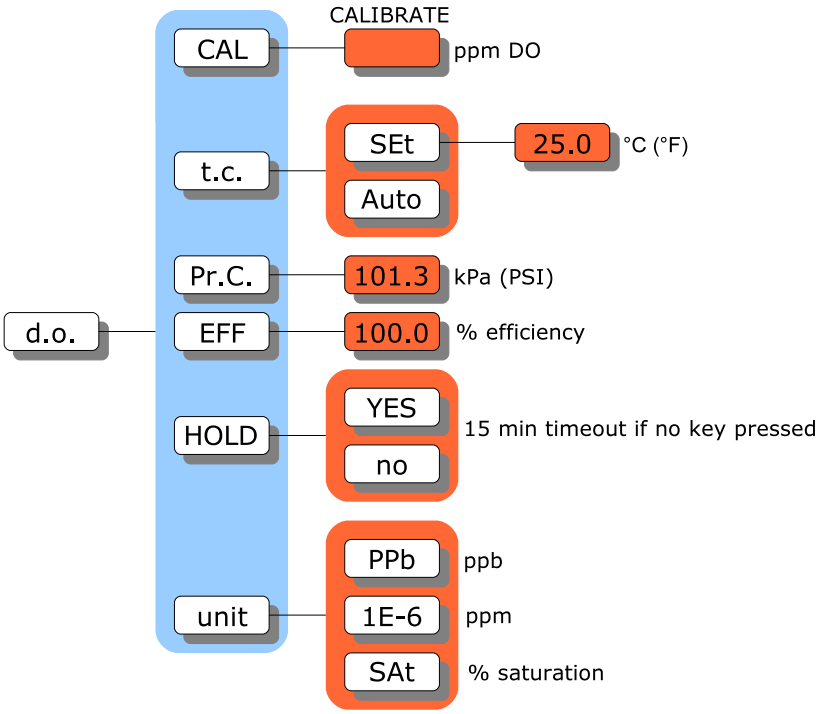


Illustration 16: Dissolved oxygen menu

Either [Auto] (for automatic temperature compensation), or [SEt] (for manual temperature compensation set-point) will be displayed, depending on the current setting. To change the setting from [Auto] to [SEt], press *ENTER* to edit the current setting. The display will start blinking, indicating that a selection needs to be made. Use the *Up* or *Down* arrow key to display [SEt]. Press *ENTER* to select manual temperature compensation.

With [SEt] still displayed, press *SELECT* to display and/or adjust the temperature setting to be used with manual temperature compensation. If the current value needs to be changed, press *ENTER* to edit the current setting; the display will start blinking. Use the *Up* or *Down* arrow key to display the desired temperature for manual temperature compensation.

Press *ENTER* to accept the displayed value.

Barometric Pressure Compensation

The 853-9 uses manual pressure compensation by way of a manual pressure compensation set-point. To see the current pressure compensation used by the analyzer during calibration and for calculation of percent saturation, select [d.o.] [Pr.C] from the menu; refer to illustration 16.

When the transmitter is calibrated, the specified pressure is used to determine the concentration of dissolved oxygen. The 100% saturation reading is affected both by temperature and by pressure. While the barometric pressure only affects the 100% saturation reading at calibration, its use reduces calibration errors that could cause readings to be off by as much as 2%.

When metric units (the default) are selected, pressure is displayed in kPa. When imperial units are selected, psi are used.

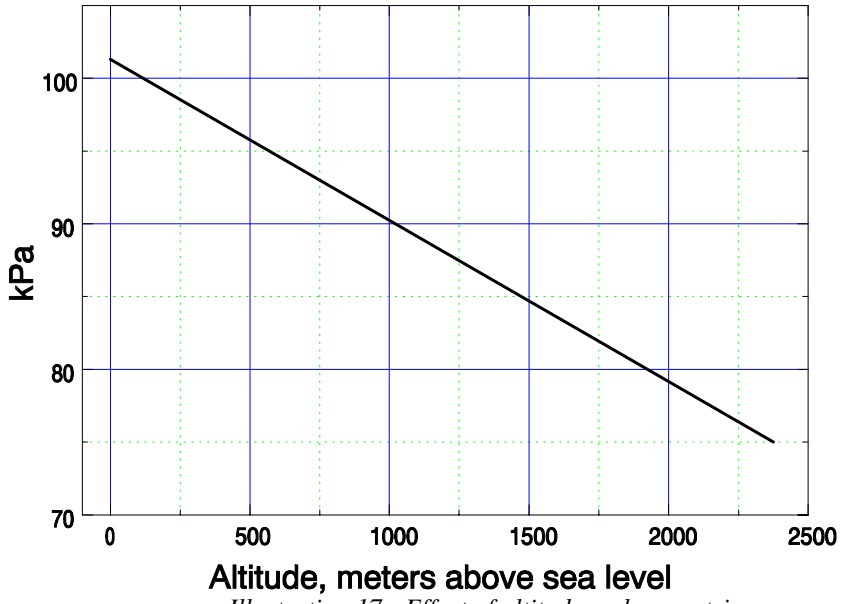


Illustration 17: Effect of altitude on barometric pressure

Calibration Procedure

When executing the calibration procedure the transmitter will adjust the efficiency constant for the D.O. cell.

Before performing the calibration, take the D.O. sensor and suspend it above water. Select [d.o.] [CAL] from the menu. The transmitter will show the D.O. reading using ppm units. The display will be blinking to indicate that the transmitter is calibrating and testing for stability.

The calibration is automatic from here on. As soon as the sensor reading has stabilized sufficiently the display will stop flashing and the new sensor efficiency constant will be calculated. The calibration setting will be based on the temperature used for temperature compensation and the pressure used for pressure compensation. The proper ppm D.O. reading is obtained from an internal table. See *Appendix D* for a table of values used by the transmitter. As soon as the display stops flashing the calibration will be completed.

It is possible to override the automatic operation of the transmitter. The *ENTER* key may be pressed before the electrode has stabilized, forcing the transmitter to calibrate using the current D.O. reading. Also, the calibration may be redone or started over at any time. Press *CANCEL* to display the [CAL] frame, then press *SELECT* to restart the calibration.

If the transmitter detects a problem during calibration, an error message will appear. If an error has been detected then the calibration was not successful and the previous calibration has been retained. Press any key to acknowledge the error message. Take corrective action and redo the calibration. Consult the error table in the *Error Messages* section for details.

Press any key to resume normal operation after an error message has appeared.

When the reading stops blinking the calibration has been completed. The reading will be displayed using the new calibration value.

After a successful calibration select [d.o.] [EFF] from the menu to inspect the new calibration value. This value is used internally to determine the transmitter gain. A good, functioning sensor will have an efficiency greater than 50%.

When leaving the calibration display, the transmitter will again display D.O. using the units used before doing the calibration. If ppb was being used then the transmitter will again display the D.O. reading as ppb when you press *SAMPLE* or leave the calibration display using the arrow keys.

Output Hold

The 853-9 allows the user to hold the output for dissolved oxygen. Output hold affects the 4 mA to 20 mA output which monitors the D.O. input.

Enable output hold by changing the [d.o.] [HOLd] setting to [YES]. Output hold has the following effect:

- 4 mA to 20 mA output signal transmitting D.O. is frozen at its current level.

The output hold remains in effect until the operator changes the [d.o.] [HOLd] setting to [no], or until no key has been pressed for 15 minutes. The 15-minute timeout ensures that output hold for D.O. will not remain in effect for longer than 15 minutes if the transmitter is left unattended.

Calibration by Grab-Sample – Sensor in line

The grab-sample technique is quicker and easier if the sensor is not easily accessible or if standard solutions are unavailable or impractical. This procedure describes how to calibrate the analyzer without taking the sensor out of the process. The procedure requires that you measure the sample with a second analyzer.

1) Obtain the following materials: second D.O. analyzer and calibration supplies for it, a clean beaker for taking a sample, and a calculator.
2) Record the 853-9 efficiency for the sensor. The efficiency is displayed by selecting [d.o.] [EFF] from the menu.
3) Draw a representative sample from the process.
4) Record the dissolved oxygen of the sample as displayed by the 853-9 transmitter.
5) Measure the dissolved oxygen of the sample using the second D.O. analyzer and record the dissolved oxygen reading. For best results the sample should be at the same temperature and the analyzers should use the same temperature compensation method.
6) Calculate the new sensor efficiency to be entered into the 853-9 transmitter using the following formula:

$$new\ efficiency = lab\ reading / [\ field\ reading / old\ efficiency\ ]$$

For example, if the 853-9 transmitter is reading 8.2 ppm, the sensor efficiency (from step 2) is 97 percent (97% = 97/100= 0.97), and the reading from the second method is 8.9 ppm then the new sensor efficiency becomes:

$$new\ efficiency = 8.9\ ppm / [8.2\ ppm / 0.97] = 1.05$$

7) Adjust the efficiency to the new value, e.g. 1.05; 105%, as in the example. The efficiency is adjusted by selecting [d.o.] [EFF] from the menu. Press *ENTER* to go into edit mode, then adjust the displayed value.

8) The analyzer should now read accurately.

Manual Calibration

It is possible to bypass the regular calibration procedures and manually edit the sensor efficiency.

When the efficiency is manually edited there is no way for the transmitter to verify the accuracy of the adjustments made. Warnings are given, however, if the edits fall outside the preset 'safe' regions. Unlike a normal calibration, the manual edits allow values outside reasonable limits. Error messages will come up but the new values will be installed nonetheless.

IC CONTROLS advises that the operator use one of the regular calibration procedures whenever possible.

4 mA to 20 mA OUTPUT SIGNAL

A 4 mA to 20 mA output is provided over the 24 VDC power leads. The output has an on/off switch and adjustable low and high. This makes it possible, for example, to transmit short span dissolved oxygen signals such as 4.0 ppm to 7.0 ppm, using the high and low adjustments.

To adjust the output span or **output "window"** for dissolved oxygen signals, set [LO] to correspond to the low end of the scale or 4 mA output, and set [HI] to correspond to the high end of the scale or 20 mA output. The transmitter will automatically scale the output according to the new settings.

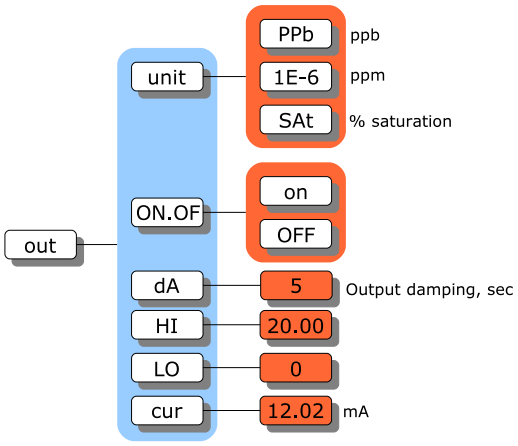


Illustration 18: Output menu

Reversing the 4 mA to 20 mA Output

The low scale setting will normally be lower than the high scale setting. It is possible to reverse the output or "flip the window" by reversing the settings of the low and high scale.

Example:
Define an output window from 7.0 ppm to 2.0 ppm with 7.0 ppm corresponding to 4 mA output and 2.0 ppm corresponding to 20 mA output. Set [LO] to 7.0 and set [HI] to 2.0.

Simulated 4 mA to 20 mA Output

Select [cur] from the menu to display the output current in mA that is presently being transmitted by this output signal. The display will be updated as the output signal changes based on the input signal and the program settings. From here you can observe the output respond to the change in the input signal. This is useful for verifying program settings and for testing the hardware calibration.

To simulate a different 4 mA to 20 mA output signal press *ENTER* to enter edit mode. Edit the displayed mA value to display the desired output needed for testing the output signal. Press *ENTER* to select the displayed value. The output signal will be adjusted to put out the desired current. This process can be repeated as often as necessary.

The output signal is held at the displayed level until the program leaves this part of the menu.

Output Specifications

	4 mA to 20 mA
Maximum span	0% to 100% scale
Span adjustment	0.1 mA steps
Output resolution	0.01 mA steps

Output Damping

The 4 mA to 20 mA output can be damped to provide the user with a means to deal with rapidly varying or noisy signals. Damping range is 0 seconds to 40 seconds. With 0 seconds, there is no output damping and each reading the transmitter makes is used to directly update the display and 4 mA to 20 mA output. The factory default 5 seconds adds the next 4 seconds of readings to the first and divides by 5 giving very fast response. Selecting 40 seconds adds the readings for all 40 seconds and divides by 40 providing an excellent smooth damping out of turbulent readings. Any selection between 0 seconds and 40 seconds can be made.

Select [out] [dA] from the menu. Press *ENTER*, then change the damping to the new number of seconds. Press *ENTER* again to leave edit mode.

CAUTION AND ERROR MESSAGES

Detected errors and/or cautions are displayed by the transmitter. From the keypad press *ERROR* or from the main menu select [Err]. If there are no error or caution messages, [NONE] will be displayed, otherwise scroll through the error list using the ↑ or ↓ keys. Errors and/or cautions cannot be removed from this list directly; each error/caution will be removed automatically when appropriate, eg. errors associated with improper calibration will be cleared after a successful calibration.

Caution and error messages are numbered. Messages 1 through 5 are identified as [E*n.e*] where *n* is the input number and *e* is the error number.

Messages 6 through 9 are less serious and are identified as cautions instead, eg. [CA*n.e*].

Off-scale errors are not numbered but are identified as [+Err] and [-Err], depending on whether the input is at the top or the bottom of the scale. The off-scale error is displayed instead of the sample reading and does not show up in the error menu with the numbered error messages, if any.

Input/Source	*Input Number for Error/Caution Messages*
Dissolved oxygen	1
Temperature	2

Table 2: Input values for error/caution messages

Error Messages for Temperature

Error	*Description*	*Causes*	*Solutions*
E2.1	Temperature reading off-scale. Temperature less than -5 °C. Display shows [-Err].	Temperature less than -5 °C.	Verify process and sensor location.
		Electronic calibration necessary.	Follow procedure in *Hardware Alignment* section.
E2.2	Temperature reading off-scale. Temperature greater than 105 °C. Display shows [+Err].	Temperature compensator not attached.	Verify process and sensor location.
		Electronic calibration necessary.	Follow procedure in *Hardware Alignment* section.

Error and Caution Messages for D.O.

Error	*Description*	*Causes*	*Solutions*
E1.0	Reading off-scale. Display shows + Err.	The internal A/D converter is at the top of the scale. The analyzer cannot measure higher dissolved oxygen values.	The analyzer is at the limit of its measuring capability. Check the sensor setup to ensure sensor is functioning properly. Service or replace the sensor if necessary.
			The analyzer needs electronic adjustments. Arrange for servicing.
E1.2	Electrode efficiency would be less than 20%. Previous setting retained.	Improper electrode setup or electrode failure.	Setup electrode, then redo calibration. Refer to *Troubleshooting* section.
E1.3	Electrode efficiency would be greater than 300%. Previous setting retained.	No D.O. signal or, signal from sensor is very weak.	Check electrode connection, then redo calibration. Refer to *Troubleshooting* section.
E1.5	Temperature compensator (TC) is off-scale.	Sample outside of TC operating range of -5 °C to 105 °C.	Use manual temperature compensation.
		TC not connected.	Check TC connections or install TC.
CA1.6	Display shows 0.00 ppm dissolved oxygen. There is no dissolved oxygen measurement.	Sensor reading is below measuring capability of analyzer.	Sensor is not connected, or there is a bad connection. Connect the D.O. sensor or check connections.
CA1.7	Display shows +Err, reading is too high for display.	Dissolved oxygen displayed using ppb units and dissolved oxygen is greater than 9,999 ppb.	Display D.O. using ppm units. Select [d.o.] [unit] from menu, set to [1E-6] to display ppm dissolved oxygen.

SENSOR INSTRUCTIONS

The dissolved oxygen sensors provided by IC Controls are designed for simple maintenance. The sensors are robust and will withstand difficult applications when properly applied and maintained. Follow instructions in this section to promote proper operation.

IMPORTANT: Galvanic D.O. sensors need a continuous current drain. Maintenance should be done with the D.O. sensor wired to it's analyzer or with sensor leads shorted coax center to shield.

Where to Perform D.O. Sensor Service

A suitable place to conduct service is at a counter or bench with a sink, in an instrument shop or laboratory. However, IC Controls dissolved oxygen supplies are kept small and portable so that they can be taken to installation sites, together with a bucket of water (for cleaning/rinsing) and a rag or towel (for wiping/drying).

Assembly of the Dissolved Oxygen Sensor

This procedure should be done over a sink. ***Wear thin plastic or rubber gloves and protective eye wear as the electrolyte is a caustic solution.*** Wash hands thoroughly with lots of water if the electrolyte comes in contact with the skin. Rinse until the slippery feel of the caustic disappears.

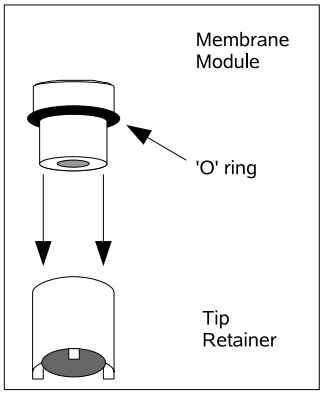


Illustration 19: Inserting membrane module

1) Galvanic D.O. sensors need to have a current drain at all times. Assemble sensor wired to analyzer or, if not possible, short the coax center to shield.
2) Unscrew the tip retainer exposing the lead coils and gold tip. Inspect the electrode to ensure the coils are clean and the gold electrode is bright.
3) Assemble a membrane module in the cap with the membrane facing down so that it covers the center hole in the cap; refer to illustration 19.
4) Flush the coils of the electrode with electrolyte solution, then holding the electrode cap in an upright position, with membrane module installed, fill with electrolyte until the center cavity is full. Tilt at about 30 degrees from vertical and add an extra 1/8 inch of electrolyte, observing that the crack around the membrane module fills with electrolyte.
5) Next hold the cap like a cup, (refer to illustration 20) and slowly lower the electrode coils vertically down into the cap until the threads touch. Rotate the sensor body until you can see the flat area through the threads. Slowly rotate the cap on, allowing the excess electrolyte and bubbles to overflow up the flat. Continue to slowly rotate the cap until a firm stop is reached.

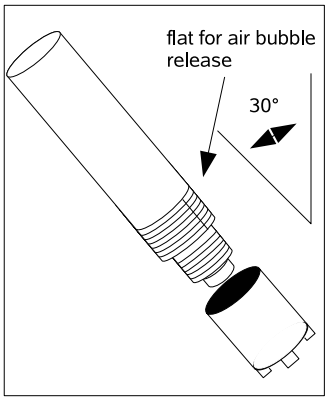


Illustration 20:Membrane cap assembly

CAUTION: ***Do not force the cap beyond the stop; the parts are plastic and can break.***

6) Dry the D.O. sensor and blot the tip. Examine the tip; the membrane should be smooth with no wrinkles or cuts and the surface contours of the gold electrode should be clear. There should be no lines from trapped bubbles between the membrane and the gold electrode. If there are no visible problems, the D.O. sensor is ready to be put into service.

D.O. Sensor Insertion into Union Fitting

1) Inspect the inside of the flow cell and/or insertion fitting for any foreign matter and wipe out any dirt which may be inside. It should appear clean, shiny and bright.
2) Feed the sensor cable through the union "ring-nut" and "push-sleeve", if not already assembled.
3) Check that the sealing O-ring is on the electrode body, on the sensing tip side of the ledge (or in the O-ring groove of the flow cell).
4) Insert the assembled and calibrated D.O. sensor into the flow cell or vessel. Gently rock the sensor back and forth to pass the O-ring and press firmly all the way down so that the O-ring firmly seats in its groove; until the D.O. sensor cannot go any further into the flow cell - the flow cell is designed with a sensor stop-point.
5) By hand, turn the union nut until tight.

CAUTION: *Do not use a large wrench to turn the union nut. The plastic could be broken or become deformed.*

NOTE: *The union insertion fitting is not intended for use at high pressure.*

Removal of D.O. Sensor from Union Fitting

1) Stop the sample flow to the dissolved oxygen sensor and vent the sample line to atmosphere.
2) If installed by insertion directly into a tank wall, ensure the level in the tank is below the sensor before removing sensor.
3) Gently rock the dissolved oxygen sensor back and forth to ease the O-ring seals back up the compression throat.
   CAUTION: *Removal of the dissolved oxygen sensor from a sealed flow cell will vacuum stretch the thin dissolved oxygen sensing membrane. Stretching the membrane will cause slow response and higher readings at low levels. Parting the membrane will cause dissolved oxygen sensor failure.*
4) When the dissolved oxygen sensor has been fully removed, wipe the sensor clean and then proceed to the calibration procedure or monthly/yearly maintenance, as necessary.

Monthly Maintenance

Certain applications may require occasional sensor cleaning. A monthly maintenance check is recommended by visual examination of the sensor cell area. If needed a soft wipe can be used to blot the area, plus detergent and water can be used to remove any deposits. Rinse thoroughly after cleaning with water. Perform a calibration and if the sensor efficiency is above 50%, return to service.

Black or red discoloration inside the sensor cap may not cause problems. However, if after calibration the electrode response is slow, replace the electrolyte and wipe the coils and surface lightly using a soft wipe, or a little more vigorous cleaning can be done using a toothbrush. Recharge with fresh electrolyte. Calibrate and return the sensor to service.

Yearly Maintenance

Replace the membrane module and electrolyte. Unscrew the electrode cap and dump the contents. Flush the cell internals with deionized water. Examine the lead coils for black or red discoloration or heavy gray coating. Such coatings should be removed for best performance. **Note:** *The lead coils are soft metal, never use force in cleaning.* Clean light fouling by wiping in the direction of the coils, until a shine appears. Heavier fouling may come off with a toothbrush, worked along the coils so the bristles get down in the cracks, followed by rinse and wiping to achieve a dull shine.

Remove the old membrane module from the cell and replace with a new one. Re-assemble the cell, calibrate, check efficiency and if above 50%, return to service.

Chemical Cleaning Maintenance

Recovery of a failing D.O. sensor can sometimes be achieved with P/N A1100194, D.O. sensor cleaning solution.

This procedure should be done over a sink. ***Wear plastic or rubber gloves and protective eye wear as the solution is acidic.*** Wash hands thoroughly with lots of water if the solution comes in contact with the skin.

1) Unscrew the tip retainer exposing the coils and gold tip. Rinse with water.
2) Immerse the coils in cleaning solution (refer to illustration 21) for 5 minutes to 10 minutes, or until deposits disappear.
3) Remove and rinse in deionized water; use a soft cloth to wipe in direction of coils or a toothbrush to speed removal.
4) Repeat steps 2 & 3 until coils and tip look clean and coils have a gray shine.

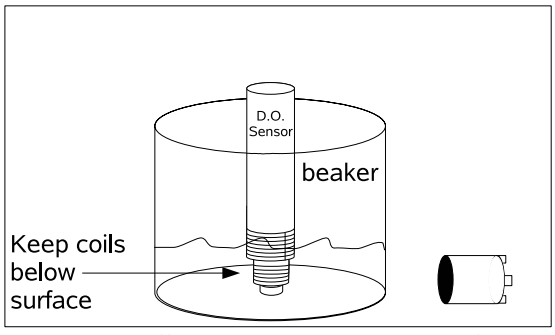


Illustration 21: D.O. Sensor cleaning

5) Re-assemble the D.O. sensor with a new membrane module (see illustration 19).

6) Fill the membrane module with fill solution and re-assemble sensor as per illustration 20.
7) Calibrate and check that efficiency is above 50%.
8) Repeat steps 2 to 7 as needed to get at least 50% efficiency. If 50% efficiency unattainable, the D.O. sensor should be replaced.

Electrode Storage

Short term: Short the sensor leads, coax center to shield. Rinse the sensor tip in deionized water, allow to dry, cover tip with a plastic shipping cap, and store dry.

Long term: Short the sensor leads, coax center to shield. Disassemble the sensor tip and discard the fill solution. Rinse the sensor internal elements and membrane module with deionized water, allow to dry, cover tip with a plastic shipping cap, and store dry.

CONFIGURATION OF PROGRAM

The 853-9 transmitter has been designed with ease-of-use in mind. In most cases the transmitter has been configured to ordered specifications at the factory and no configuration of the transmitter is necessary. However, several hardware options are available and if they are changed, the program configuration settings need to be set accordingly for the program to function properly.

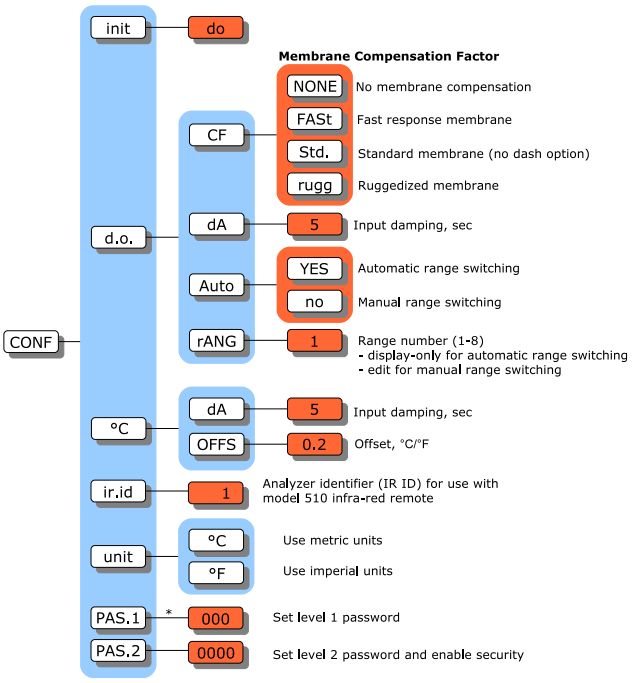


Illustration 22: Configuration menu

Initializing All Program Settings

Occasionally it may be desirable to reinitialize all of the program settings to bring them back to default. Executing the initialization procedure will cause the transmitter to reset all the program variables and settings to factory default and then proceed with the normal startup display.

The initialization procedure is not to be used unless the user is absolutely sure that they want to restore the transmitter to factory default configuration. Select [CONF] [init] from the menu. The display will flash [do]. Nothing will happen if at this point you press *SAMPLE* or ←. The transmitter will be -initialized when the user presses *ENTER*.

After the transmitter program has been initialized, the user will need to re-enter the output signal settings, as well as the program configuration if it was different from the factory default settings.

Input Damping

Both the measurement and the temperature can be damped to provide the user with a means to deal with rapidly varying or noisy signals. Damping range is 0 seconds to 40 seconds. With 0 seconds, there is no damping and each reading the transmitter makes is used to directly update the display and 4 mA to 20 mA output. The factory default 5 seconds adds the next 4 seconds of readings to the first and divides by 5 giving very fast response. Selecting 40 seconds adds the readings for all 40 seconds and divides by 40 providing an excellent smooth damping out of turbulent readings. Any selection between 0 seconds and 40 seconds can be made.

Select [CONF] [d.o.] or [°C] [dA] from the menu. Press *ENTER*, then change the damping to the new number of seconds. Press *ENTER* again to leave edit mode.

Temperature Calibration

The temperature compensator in the D.O. sensor can sometimes show a small variance in it's offset. To make the sensor read correctly without adjusting the electronic calibration of the transmitter, use the following procedure.

The current temperature, as measured by the temperature sensor, needs to be known. If the sensor is in the process, the known temperature of the process can be used.

Select [CONF] [°C] [OFFS] from the menu. A frame showing the current temperature offset will be displayed.

Use the following formula to calculate the new offset value:

$$offset_{new} = T_{correct} - T_{displayed} + offset_{current}$$

For example, if the temperature input is reading 24.6 °C but it should be reading 25.0 °C and the current offset is 0.2 °C:

$$offset_{new} = 25.0\,°C - 24.6\,°C + 0.2\,°C = 0.6\,°C$$

The calculation works both for Celsius and Fahrenheit units.

Select [CONF] [°C] [OFFS] from the menu. Press *ENTER*, then change the temperature offset to the new offset value. Press *ENTER* again to leave edit mode.

Return to the sample menu and verify that the temperature input is now displaying the correct temperature.

Metric or Imperial Units

By default the transmitter will use metric units. This means that temperature will be displayed using degrees Celsius and that the prompt for the temperature input will be [°C]. However, the transmitter can be made to use imperial units. Using imperial units, temperature will be displayed using degrees Fahrenheit and the prompt for the temperature input will be [°F].

For practical reasons, the temperature input is identified as [°C] throughout this instruction manual and in the menus.

To select imperial units for the transmitter, select [unit] from the configuration menu, then go into edit mode and change the [°C] prompt to [°F].

Infra-Red Identity

When mounted close together, more than one transmitter could possibly see the signals from a single 510 infra-red remote keypad. Normally, only one transmitter is located at a particular site so all transmitters respond to all 510 IR signals. To make the transmitters individually selectable they have a unique ID capability. IC Controls ships the units with ID equal to 01 by default; it can be field changed to any two digit number up to 99. Where an array is planed it is easiest to preset the ID to a unique number before installation. However, by stepping *close enough* that *only one unit* sees the signal, the ID can be changed in the installation.

Select [CONF] [ir.id] [01] from the menu. Press *ENTER*, then change the ID number to the new number you want. Press *ENTER* again to leave edit mode.

Membrane Selection

Dissolved oxygen sensor models 802 and 825 can be ordered with a choice of membranes:

Standard membrane; no dash option specified.
Fast response membrane; thinner and less durable, specified with -4 option.
Ruggedized membrane; thicker and slower response, specified with -5 option.

For more accurate response, the analyzer configuration should be adjusted to reflect the membrane used by the sensor.

From the menu select [CONF] [d.o.] [CF], then select the appropriate membrane.

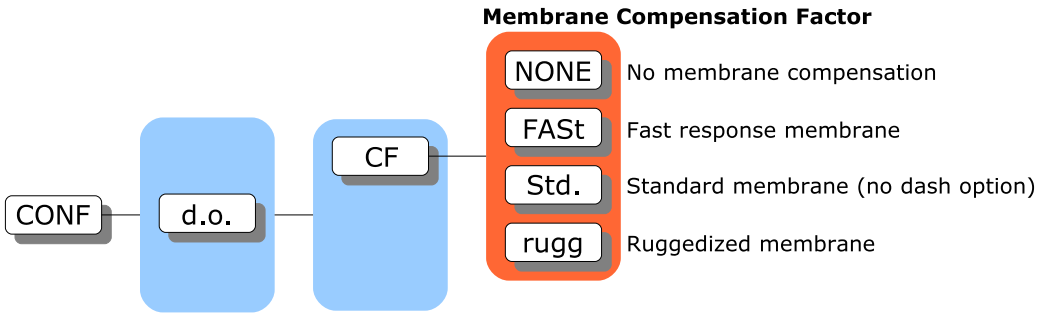


Illustration 23: D.O. membrane compensation factor menu

TROUBLESHOOTING

Slow Response
Typically due to excessive sample line length and low flow, producing long sample transport lags. Resolve by adding a fast-flow loop with the sensor in a short side stream, or by shortening the line.

Slow response can also be caused by a buildup of dirt in the sample line. In this case, the problem may be alleviated by changing the take-off point or by installing a knock-out pot. Alternatively, a dirty-water sample system may be needed.

Readings consistently low or spike low
Characteristic of wiring problems between the analyzer and the sensor; an open circuit in the field wiring will result in zero cell current and a very low reading. Review the installation instructions.

Readings gradually falling
The analyzer can no longer be calibrated properly. This problem is typical of scale or sludge/slime deposits on the sensor face; the sensor will need to be cleaned. Refer to the *Chemical Cleaning Maintenance* section in this manual.

Readings at maximum - "+Err" message under all conditions
Usually an indication that the D.O. sensor is in air but still set to display in ppb oxygen. Caution 1.7 will appear in the error menu. Select [d.o.] [unit] from the menu, then set units to ppm ([1E-6] frame). With units as ppm, displayed readings can be greater than 10 ppm or 9,999 ppb. "+ Err" message means off-scale high.

Readings trend where expected but spike high
This problem is typical of air bubbles in the sample line. If a bubble hangs up in the D.O. flow cell, a high surge that slowly falls over some hours may be observed. Correct by finding air in-leakage point and stopping leak.

ELECTRONIC HARDWARE ALIGNMENT

Instrument Shop Procedure

The following instructions are intended for instrument personnel to adjust the transmitter if necessary. This procedure should be performed in an instrument shop or safe area location.

****** Do not perform electronic adjustments in the field ******

Devices referred to in the following descriptions are shown on component location drawing D5000230. Proper field wiring hookup is shown on drawing D5020256.

These instructions assume 24 VDC power is hooked up, the calibration of input electronics are operable, and 24 VDC wiring is in place.

Calibration of ppm Dissolved Oxygen Circuit

Alignment of dissolved oxygen input

1. Hook up the black lead of a voltmeter to TB100, terminal 2 (REF), found in terminal end of housing.
2. Hook up the red lead of a voltmeter to test-point "DO" located in the center of main board.
3. Using a DATEL mV simulator (or equivalent), input 0.12 VDC through a 100K resistor to the TB100, terminal 4 (DO +) sensor connection and TB100, terminal 2, as common. In the transmitter [d.o.] menu, set [EFF] to 100% and [t.c.] [SET] to 25°C.
4. Measure test voltage at test-point marked "DO" (Pin 7 of U102); it should be 0.650 VDC. Adjust "DO" voltage using gray trim-pot VR100.

Alignment of dissolved oxygen output

1. Hook up the black lead of a voltmeter to TP3 (common) test-point on main board.
2. Hook up the red lead of a voltmeter to TP1 test-point on top left of main board (U107 pin 7).
3. Input remains the same as step 3 in *Alignment of dissolved oxygen input* above; test voltage at TP1 should be 1.2 VDC. Adjust voltage using R118 on main board.

Calibration of Temperature Input

The temperature input of the 853-9 is so reliable that no adjustable electronic parts are needed. The stability and repeatability of the 1000 ohm RTD temperature circuit typically needs no adjustment. Adjustments often lead to lower accuracy due to the difficulty of knowing the true temperature without a controlled temperature bath. Any necessary minor adjustments are handled by the software. To adjust the temperature input, refer to the heading entitled “Temperature Calibration” in the *Configuration of Program* section.

DISPLAY PROMPTS

[1E-6]	Parts per million; dissolved oxygen unit.
[Acc.n]	Access level for security. Displayed after password entered by user.
[Auto]	Automatic.
[°C]	Temperature in degrees Celsius; temperature input.
[CAL]	Calibrate transmitter.
[CF]	Compensation factor; dissolved oxygen membrane.
[CONF]	Configuration of program to match hardware.
[cur]	Signal output in mA, or current.
[dA]	Damping; input and/or output.
[d.o.]	Dissolved oxygen input.
[do]	Do - press ENTER to do reset/clear action.
[donE]	Done – reset/clear action has been accepted.
[EFF]	Dissolved oxygen cell efficiency constant; as percent efficiency.
[Err]	Error.
[Fast]	Fast response membrane.
[°F]	Temperature in degrees Fahrenheit.
[HI]	High limit (20 mA) for 4 mA to 20 mA output window.
[Hold]	Output hold during calibration.
[init]	Re-initialize transmitter to default settings.
[ir.id]	Infra-red identity number, editing (change) frame.
[LO]	Low limit (4 mA) for 4 mA to 20 mA output window.
[NONE]	No membrane compensation.
[OFF]	Off.
[OFFS]	Offset.
[on]	On.
[ON.OF]	On/Off switch.
[out]	4 mA to 20 mA analog output channel.
[PAS.1]	Set password 1, operator access.
[PAS.2]	Set password 2, complete access.
[PASS]	Enter password to change access level.
[PPb]	Parts per billion; dissolved oxygen unit.
[Pr.C.]	Pressure compensation setting.
[rANG]	Range number.
[rugg]	Ruggedized membrane.
[SAt]	Percent saturation; dissolved oxygen unit.
[SEt]	Set-point; select manual temperature compensation.
[Std.]	Standard membrane.
[t.c.]	Temperature compensation.
[unit]	Unit selection.

GLOSSARY

EPROM (Erasable/Programmable Read Only Memory)
The EPROM chip holds the program which determines the functioning of the 853-9 transmitter. The customer settings in the EPROM chip will not disappear even if the chip loses power.

IR Remote
Infra-red operated remote keypad. When the infra-red light is aimed at the infra-red detector, behind the glass inside the explosion proof housing, the electronics reads the signal without needing any holes for keypad wires. The message is passed by high speed light pulses.

Menu
The series of prompts which determine the layout of the program used by the transmitter.

Microprocessor
An integrated circuit (chip) which executes the program in the EPROM and controls all the input/output functions.

ppb
Concentration dissolved oxygen in parts per billion.

ppm
Concentration dissolved oxygen in parts per million.

RAM (Random Access Memory)
Memory in a RAM chip can be both written to and read from. The contents of RAM will disappear as soon as the RAM chip loses power. The RAM chip has a battery backup device which preserves the contents of the RAM chip for a considerable time even if the transmitter is turned off. Al settings are stored in RAM.

TC
Temperature compensator.

Temperature Compensation
Correction for the influence of temperature on the sensing electrode. The transmitter reads out concentration as if the process were at 25 °C, regardless of actual solution temperature.

Appendix A — Default Settings

The following program settings are the default settings for the transmitter. New transmitters will have these settings unless the setup has already been customized for the user's specific application.

Outputs

Input to be transmitted:	Dissolved Oxygen
Low setting:	0.00 ppm
High setting:	10.0 ppm
ON/OFF switch:	ON
Units:	ppm [1E-6]

Global units

Metric units; temperature in degrees Celsius, °C, (degrees Fahrenheit, °F, selectable).

Dissolved oxygen units selectable for ppm, ppb, or percent saturation.

Security

Not enabled

Temperature compensation method

Automatic TC using temperature input

Input signal damping

Signal damping for:	Dissolved oxygen =	5 seconds
	Temperature =	5 seconds

Output signal damping

4 mA to 20 mA output damping = 5 seconds

Appendix B — Parts List

Part Number	*Description*	*Reference Drawing Number*
853-9 pH or ORP Transmitter		
A9051052	Assembly; 853-9 D.O. main PCB	D5000230-R1.0
A9051046	Assembly; M53-9 micro board	D5000224-R1.0
A9051045	Assembly; M53-9 display PCB, complete	D5000223-R1.0
A9051047	Assembly; M53-9 feed-through PCB	D5000225-R1.0
A9051053	Assembly; 853-9 D.O. front panel	
A9141026	Assembly; M53-9 case, complete	
A2500270	2 inch pipe mount kit; M53-9 series	D4000076
Consumable Supplies		
A2103015	Membrane module and fill solution kit; normal response	
A2103013	Membrane module and fill solution kit; fast response	
A2103017	Membrane module and fill solution kit; rugged response	
A1100193	Zero D.O. check solution, 500 mL bottle	
A1100194	D.O. sensor internal cleaning solution, 500 mL bottle	
A1100192	Deionized rinse water, 500 mL (A11000192-6P for 6-pack)	
A1100020	Plastic beaker, 250 mL; for field calibrations	
A7400031	Syringe, 120 mL; for rinsing electrode tip	

Appendix C – 853-9 Specifications

Physical Data	
PROPERTY	***CHARACTERISTIC***
Display	Four and one half LCD digits, 1.5 cm (0.6 in) displays for dissolved oxygen, temperature, error codes, prompts and diagnostic information
Display Ranges	Dissolved Oxygen: 0 mg/L to 20 mg/L *or* 0 µg/L to 9,999 µg/L *or* 0% to 100% saturation Temperature: -5 °C to 105 °C (23 °F to 221 °F)
Operation	Via intrinsically safe infra-red remote control.
Enclosure	Explosion proof, barrel housing
Mounting	Any 90 degree increment from standard; supplied with 2 in pipe mounting kit (*may be used to surface mount*).
Weight	3.5 kg (7.7 lb)
Shipping Weight	4.1 kg (9.0 lb)
Shipping Dimensions	46 cm × 30 cm × 23 cm (18 in × 12 in × 9 in)

Environmental Data	
PROPERTY	***CHARACTERISTIC***
Temperature	Operational: 5.0 °C to 45 °C (41.0 °F to 113 °F) Storage: -10.0 °C to 55 °C (14.0 °F to 131 °F) Relative Humidity: 80 % maximum; non-condensing
Enclosure Ratings	-Class 1 Groups B, C & D; Class 2 Groups E, F & G rating. -NEMA 4, watertight, dustile rating. -NEMA 7, hazardous; for indoor use Class 1, Groups A, B, C & D as defined by NEC. -FM Approved. -CSA certified. -Cenelec Certified, EExd IIC, IP66.
Electrical Ratings	24 VDC (min. 16 VDC, max. 40 VDC); lift off voltage 16 VDC; 4 to 20 mA.
Electrical Requirements	16 VDC to 40 VDC, 24 VDC nominal. Quality ground required for microprocessor.

Operational Data	
PROPERTY	***CHARACTERISTIC***
Accuracy	Dissolved Oxygen: ± 0.5 % of measured range Temperature: ± 0.3 °C
Precision	Dissolved Oxygen: ± 1 digit (0.01 mg/L) Temperature: ± 1 digit (0.1 °C)
Response Time	90% within 5 s (default), function of flow and temperature. Damping adjustment: 0 s to 60 s
Temperature Compensation	Automatic 1000 Ω RTD Auto: -5 °C to 105 °C (23 °F to 221 °F) Manual: -5 °C to 105 °C (23 °F to 221 °F)
Output	One continuous, programmable 4 mA to 20 mA output; isolated, max. load 500 Ω. Convertible to 1 VDC to 5 VDC.

Appendix D — Saturated D.O. Values

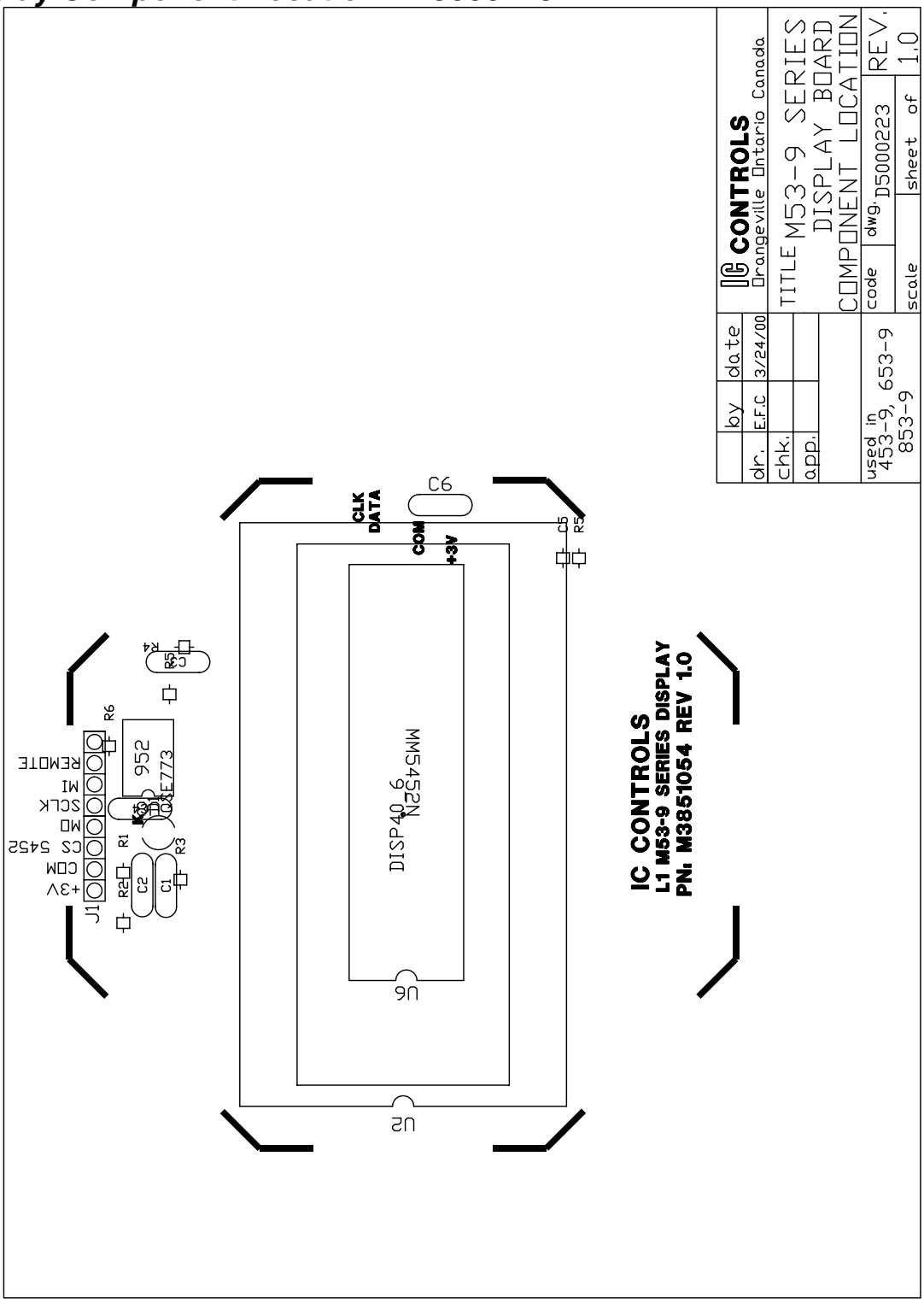
The table below lists shows the concentration of dissolved oxygen in water over a range of temperature and pressure. Dissolved oxygen values are reported as parts per million. During calibration, the 855 analyzer uses the table below to determine the efficiency of the cell. The column for atmospheric pressure, $1\,atmosphere = 101.3\,kPa$, is in italics.

°C/kPa	***94.0***	***95.0***	***96.0***	***97.0***	***98.0***	***99.0***	***100.0***	***101.0***	***101.3***	***102.0***	***103.0***	***104.0***	***105.0***	***106.0***
0	13.51	13.65	13.80	13.94	14.09	14.23	14.37	14.52	***14.57***	14.67	14.811	14.95	15.10	15.25
1	13.15	13.29	13.43	13.57	13.71	13.85	13.99	14.13	***14.17***	14.27	14.41	14.56	14.70	14.84
2	12.79	12.93	13.06	13.20	13.34	13.48	13.61	13.75	***13.79***	13.88	14.02	14.16	14.30	14.43
3	12.46	12.59	12.72	12.86	12.99	13.13	13.26	13.39	***13.43***	13.52	13.66	13.79	13.93	14.06
4	12.13	12.25	12.38	12.52	12.65	12.77	12.90	13.04	***13.08***	13.17	13.29	13.42	13.56	13.69
5	11.82	11.95	12.07	12.20	12.33	12.45	12.58	12.71	***12.74***	12.83	12.96	13.09	13.21	13.34
6	11.52	11.64	11.76	11.89	12.01	12.13	12.25	12.38	***12.42***	12.50	12.62	12.75	12.87	13.00
7	11.23	11.36	11.48	11.60	11.72	11.84	11.96	12.08	***12.11***	12.20	12.32	12.44	12.56	12.68
8	10.95	11.07	11.19	11.30	11.42	11.54	11.66	11.77	***11.81***	11.89	12.01	12.13	12.25	12.37
9	10.69	10.81	10.93	11.04	11.15	11.27	11.39	11.50	***11.53***	11.61	11.73	11.85	11.96	12.08
10	10.44	10.55	10.66	10.77	10.89	11.0	11.11	11.22	***11.26***	11.34	11.45	11.56	11.67	11.79
11	10.20	10.31	10.42	10.52	10.64	10.75	10.86	10.96	***10.99***	11.08	11.19	11.30	11.40	11.52
12	9.96	10.07	10.17	10.28	10.39	10.50	10.60	10.71	***10.74***	10.82	10.93	11.03	11.14	11.24
13	9.74	9.84	9.95	10.05	10.16	10.26	10.37	10.47	***10.50***	10.58	10.68	10.79	10.89	11.00
14	9.52	9.62	9.72	9.83	9.93	10.03	10.13	10.24	***10.27***	10.34	10.44	10.54	10.65	10.75
15	9.31	9.41	9.52	9.62	9.72	9.81	9.92	10.02	***10.05***	10.12	10.22	10.32	10.42	10.52
16	9.11	9.21	9.31	9.41	9.51	9.60	9.70	9.80	***9.83***	9.90	10.00	10.10	10.20	10.28

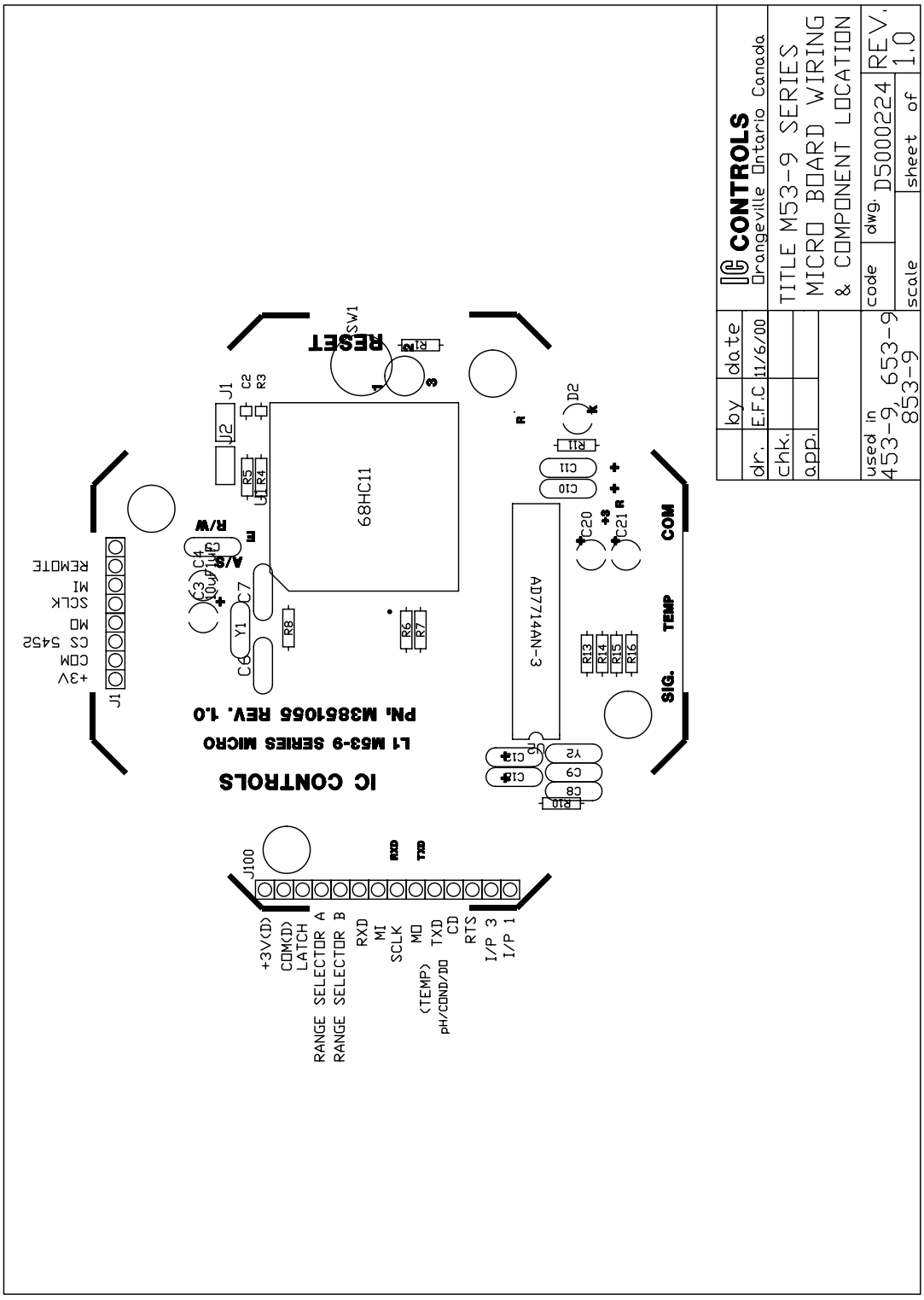
°C/kPa	*94.0*	*95.0*	*96.0*	*97.0*	*98.0*	*99.0*	*100.0*	*101.0*	*101.3*	*102.0*	*103.0*	*104.0*	*105.0*	*106.0*
17	8.92	9.02	9.12	9.21	9.31	9.41	9.50	9.60	***9.63***	9.70	9.79	9.89	9.99	10.08
18	8.74	8.83	8.92	9.02	9.12	9.21	9.30	9.40	***9.43***	9.50	9.59	9.68	9.78	9.87
19	8.56	8.66	8.75	8.84	8.93	9.03	9.12	9.21	***9.24***	9.31	9.40	9.49	9.58	9.67
20	8.39	8.48	8.57	8.66	8.75	8.84	8.93	9.03	***9.06***	9.12	9.21	9.30	9.39	9.47
21	8.23	8.32	8.41	8.50	8.59	8.67	8.76	8.85	***8.88***	8.95	9.04	9.13	9.21	9.30
22	8.07	8.15	8.24	8.33	8.42	8.51	8.59	8.68	***8.71***	8.77	8.86	8.95	9.03	9.12
23	7.92	8.00	8.09	8.18	8.26	8.35	8.44	8.52	***8.55***	8.61	8.70	8.79	8.87	8.96
24	7.77	7.85	7.94	8.02	8.11	8.19	8.28	8.36	***8.39***	8.45	8.53	8.62	8.70	8.79
25	7.63	7.71	7.80	7.88	7.96	8.04	8.13	8.21	***8.24***	8.30	8.38	8.47	8.55	8.64
26	7.49	7.57	7.65	7.73	7.82	7.90	7.98	8.06	***8.09***	8.15	8.23	8.31	8.39	8.48
27	7.36	7.44	7.52	7.60	7.68	7.76	7.84	7.92	***7.95***	8.01	8.09	8.17	8.25	8.33
28	7.23	7.31	7.38	7.46	7.55	7.63	7.70	7.78	***7.81***	7.87	7.95	8.02	8.10	8.18
29	7.10	7.18	7.26	7.34	7.42	7.50	7.57	7.65	***7.68***	7.73	7.81	7.89	7.79	8.05
30	6.98	7.06	7.13	7.21	7.29	7.37	7.44	7.52	***7.55***	7.60	7.68	7.76	7.84	7.91
31	6.87	6.94	7.02	7.09	7.17	7.25	7.32	7.40	***7.42***	7.48	7.55	7.63	7.71	7.78
32	6.75	6.83	6.90	6.98	7.05	7.13	7.20	7.28	***7.30***	7.35	7.43	7.50	7.58	7.65
33	6.64	6.71	6.79	6.86	6.94	7.01	7.09	7.16	***7.18***	7.23	7.31	7.38	7.46	7.53
34	6.53	6.60	6.67	6.75	6.82	6.90	6.97	7.05	***7.07***	7.12	7.19	7.26	7.34	7.41
35	6.42	6.49	6.57	6.64	6.71	6.79	6.86	6.93	***6.95***	7.00	7.07	7.15	7.22	7.30
36	6.32	6.39	6.46	6.53	6.60	6.68	6.75	6.83	***6.84***	6.89	6.96	7.03	7.11	7.18
37	6.22	6.28	6.36	6.43	6.50	6.57	6.64	6.71	***6.73***	6.78	6.85	6.92	7.00	7.07
38	6.12	6.18	6.25	6.33	6.40	6.46	6.53	6.61	***6.63***	6.68	6.74	6.81	6.89	6.95
39	6.02	6.09	6.16	6.23	6.30	6.36	6.43	6.50	***6.52***	6.57	6.64	6.71	6.78	6.85
40	5.93	5.99	6.06	6.13	6.20	6.26	6.33	6.40	***6.42***	6.47	6.53	6.60	6.68	6.74
41	5.83	5.90	5.97	6.03	6.10	6.16	6.23	6.30	***6.32***	6.37	6.43	6.50	6.57	6.64
42	5.74	5.80	5.87	5.94	6.00	6.06	6.13	6.20	***6.22***	6.27	6.33	6.40	6.47	6.53
43	5.64	5.71	5.78	5.84	5.91	5.97	6.04	6.10	***6.13***	6.17	6.24	6.30	6.37	6.43
44	5.55	5.61	5.68	5.75	5.82	5.88	5.94	6.01	***6.03***	6.08	6.14	6.20	6.27	6.33

DRAWINGS

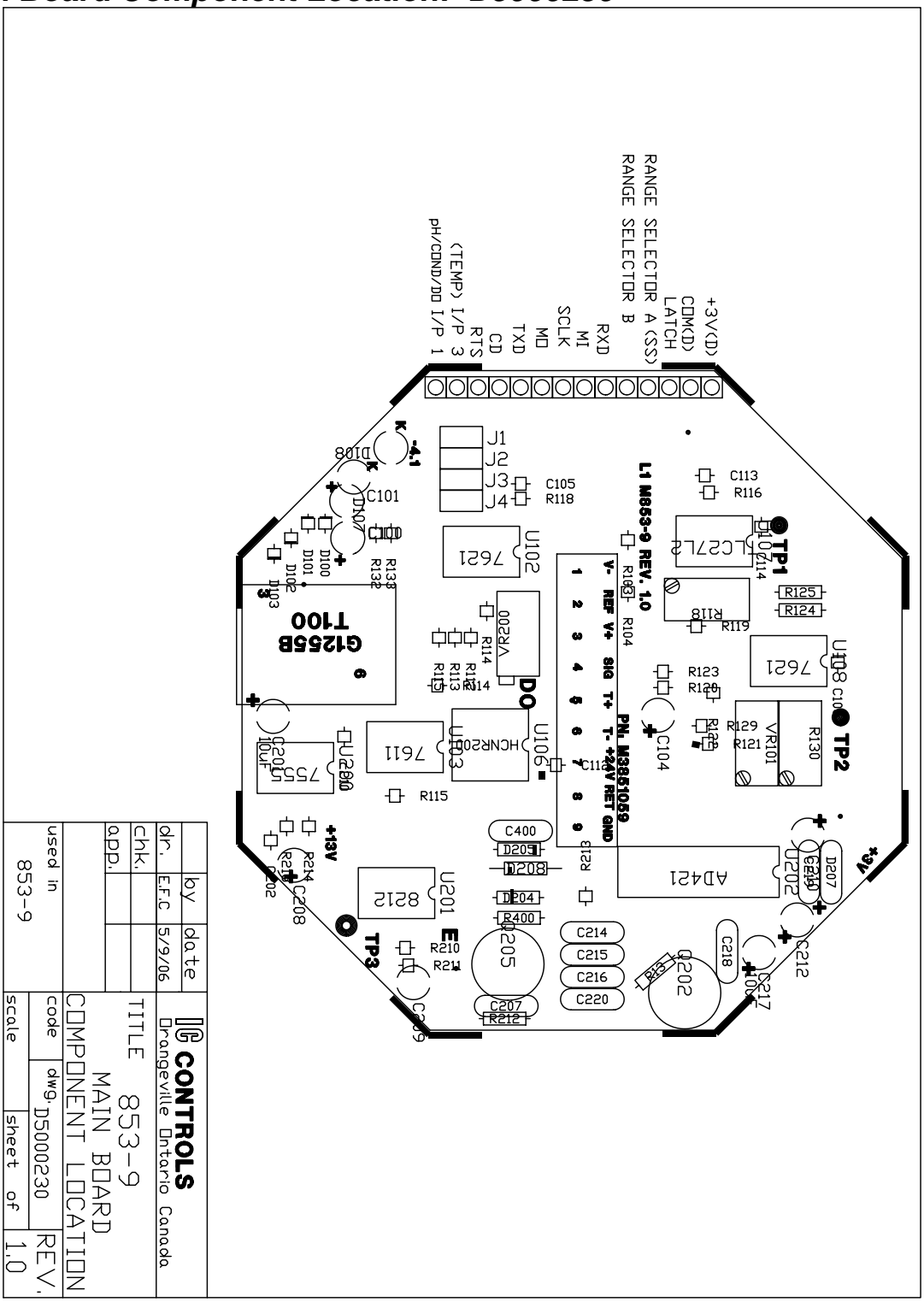
Display Component Location: D5000223



Micro Board Wiring & Component Location: D5000224



Main Board Component Location: D5000230



	by	date
dr.	E.F.C	5/9/06
chk.		
app.		

IC CONTROLS Orangeville Ontario Canada

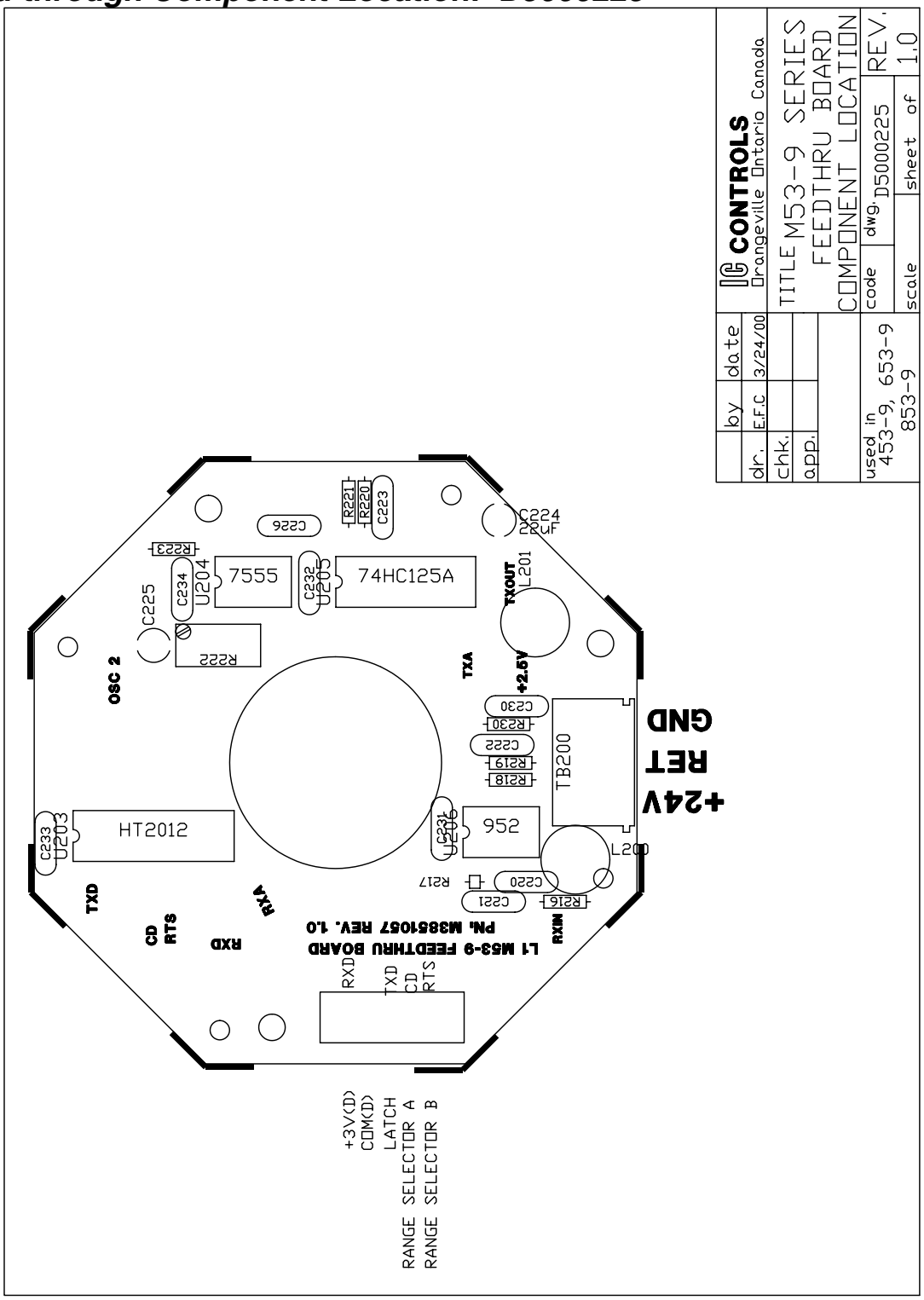
TITLE 853-9 MAIN BOARD COMPONENT LOCATION

used in 853-9

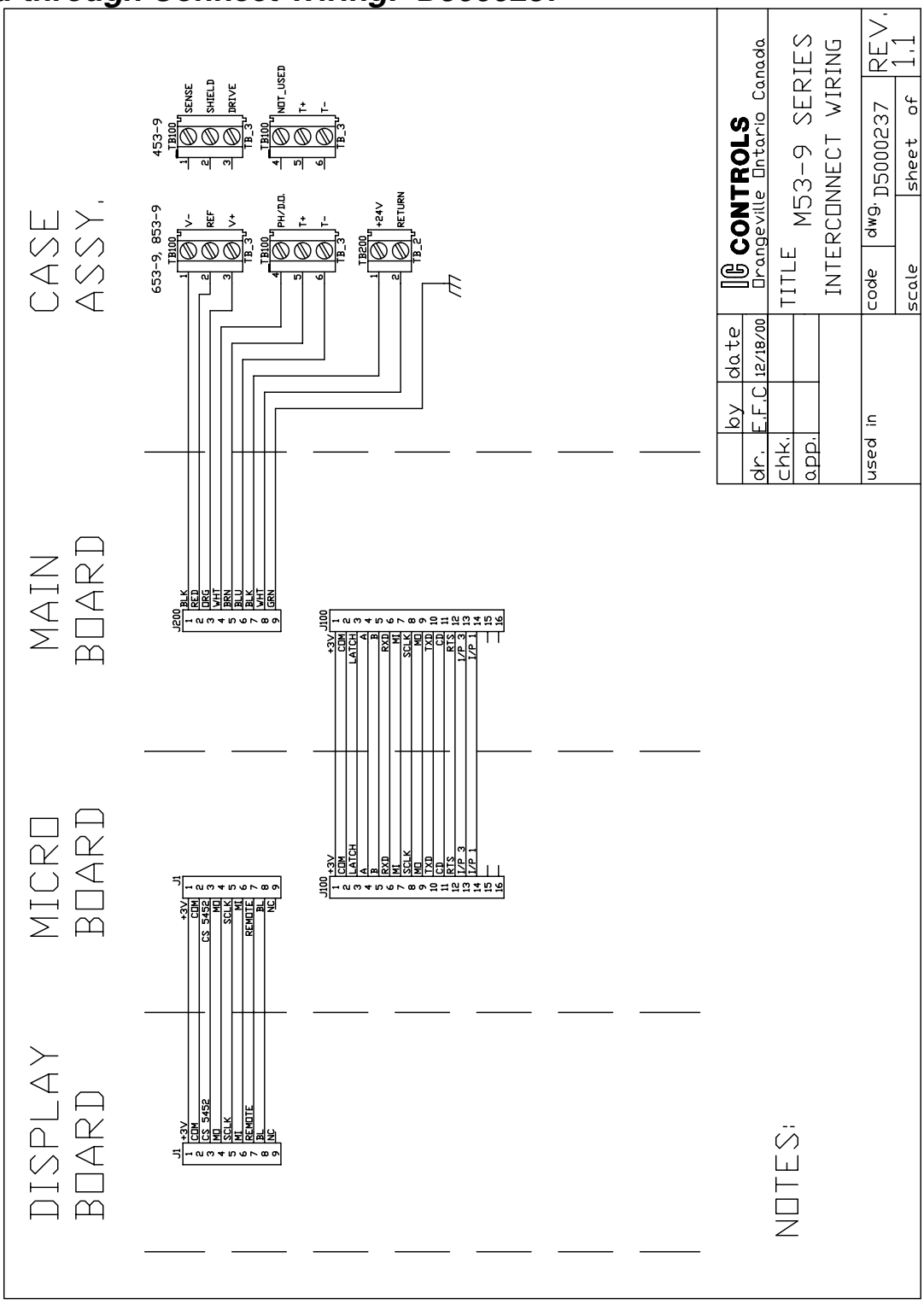
code | dwg: D5000230 | REV. 1.0

scale | sheet of

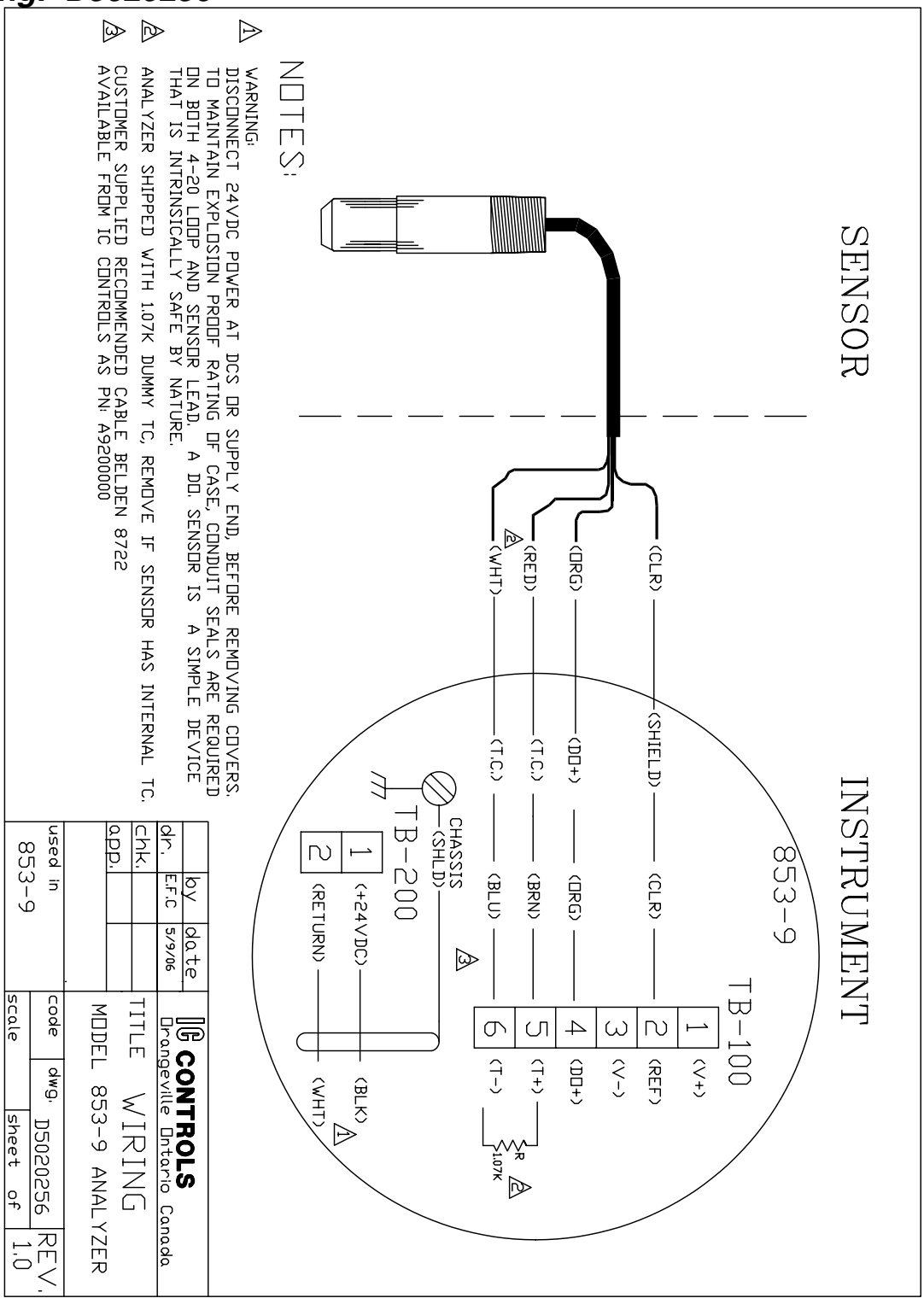
Feed-through Component Location: D5000225



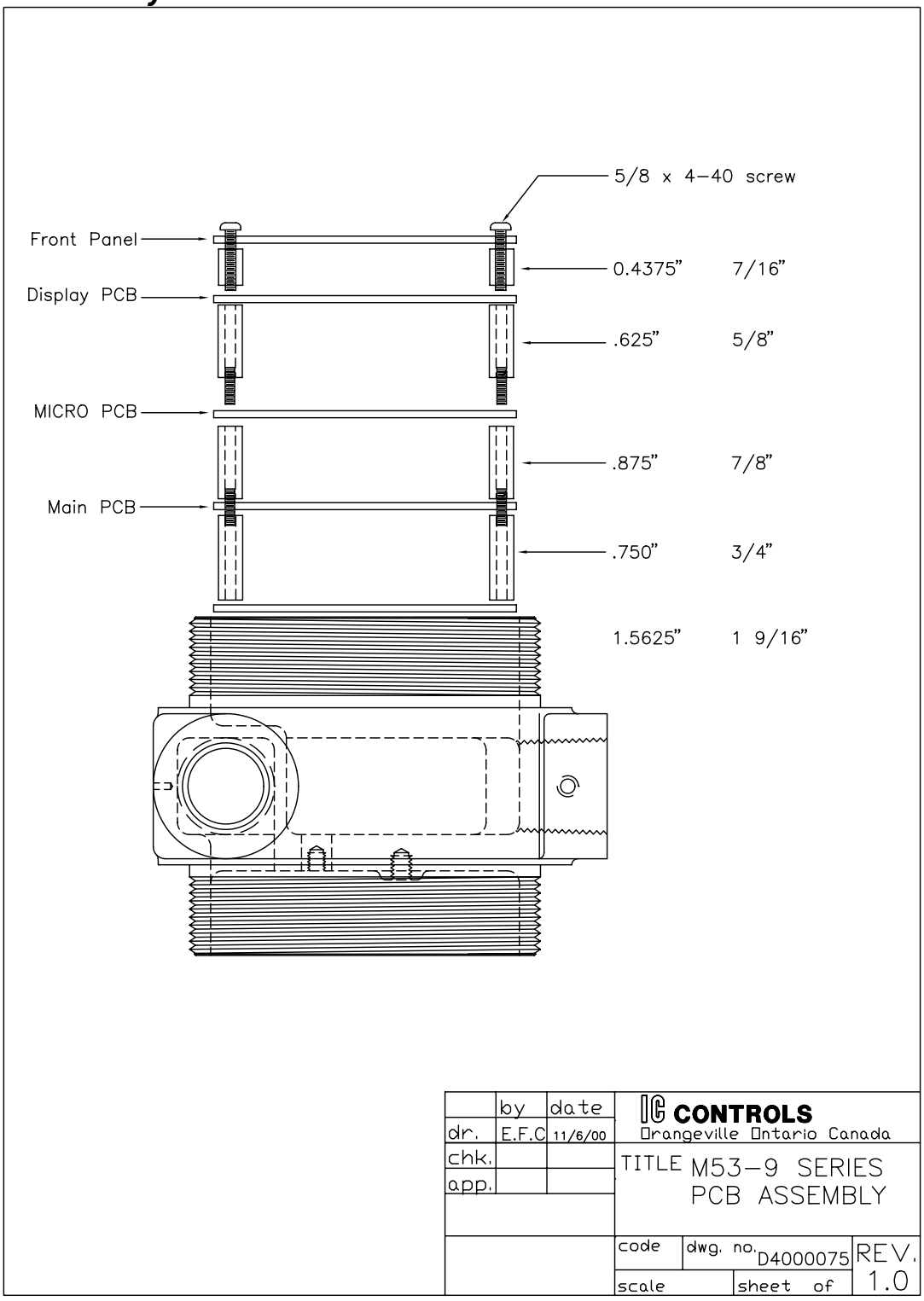
Feed-through Connect Wiring: D5000237



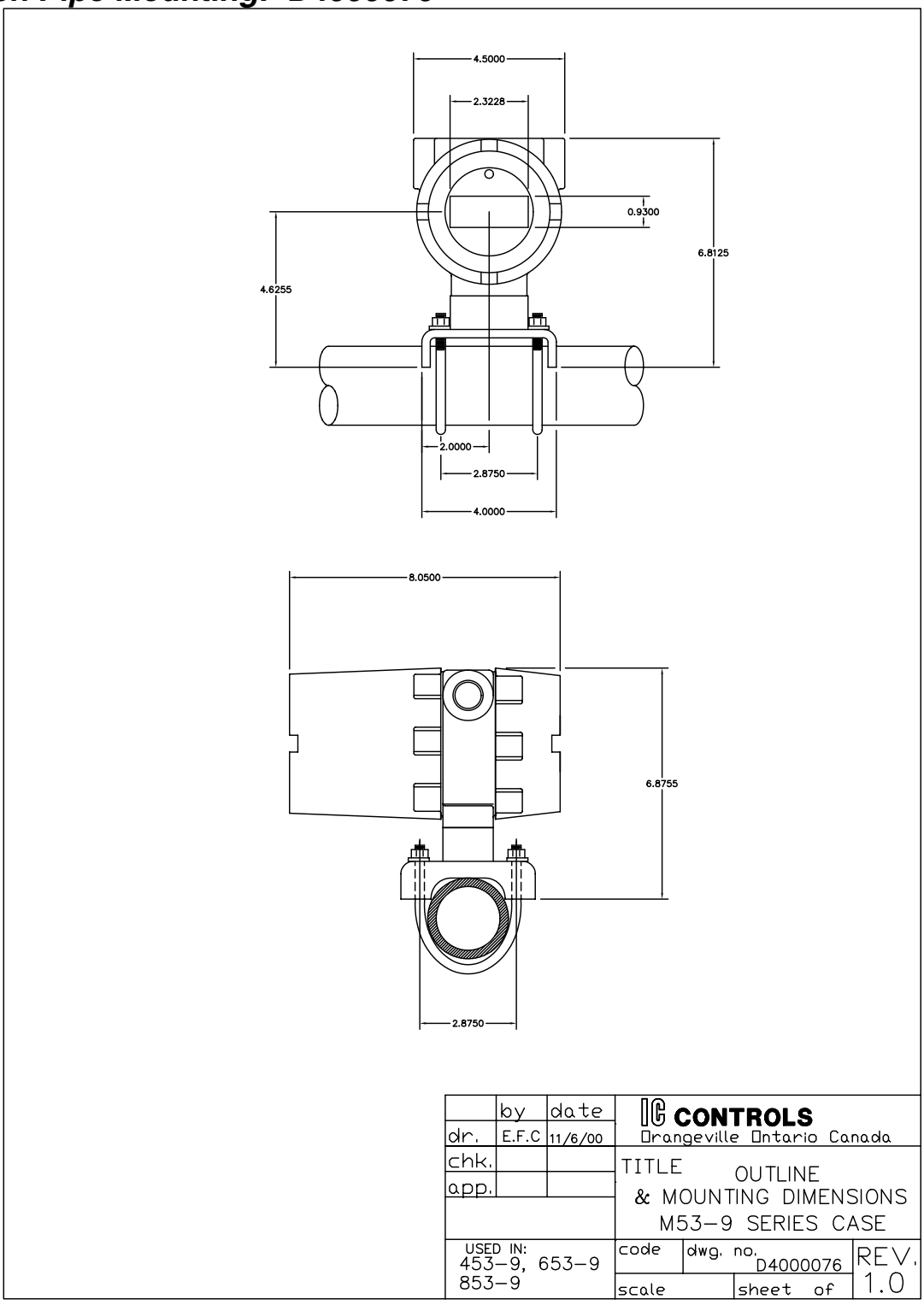
Wiring: D5020256



PCB Assembly: D4000075



2 inch Pipe Mounting: D4000076



	by	date
dr.	E.F.C	11/6/00
chk.		
app.		

IC CONTROLS
Orangeville Ontario Canada

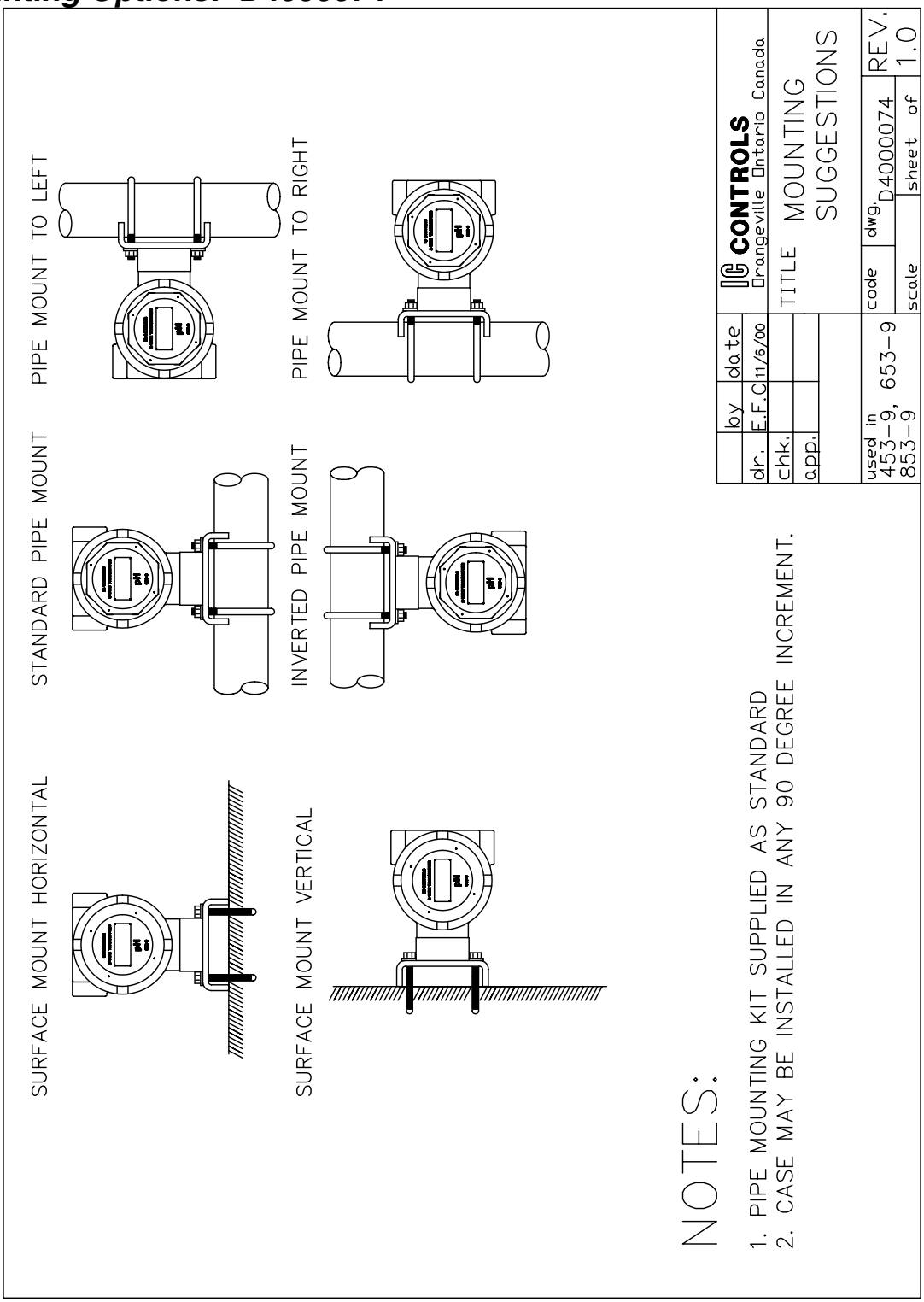
TITLE OUTLINE & MOUNTING DIMENSIONS M53-9 SERIES CASE

USED IN: 453-9, 653-9 853-9

code | dwg. no. D4000076 | REV. 1.0

scale | sheet of

Mounting Options: D4000074



IC CONTROLS LTD. Head Office, Manufacturing & Research
29 Centennial Road, Orangeville, Ontario, L9W 1R1 Canada Tel: (519) 941-8161 Fax: (519) 941-8164

INDUSTRIAL PRODUCTS WARRANTY

Industrial instruments are warranted to be free from defects in material and workmanship for a period of twelve (12) months from the date of installation or eighteen (18) months from the date of shipment from IC CONTROLS whichever is earlier, when used under normal operating conditions and in accordance with the operating limitations and maintenance procedures in the instruction manual, and when not having been subjected to accident, alteration, misuse, or abuse. This warranty is also conditioned upon calibration and consumable items (electrodes and all solutions) being stored at temperatures between 5 °C and 45 °C (40 °F and 110 °F) in a non-corrosive atmosphere. IC CONTROLS consumables or approved reagents must be used or performance warranty is void. Accessories not manufactured by IC CONTROLS are subject to the manufacturer's warranty terms and conditions.

Limitations and exclusions:

Industrial electrodes, and replacement parts, are warranted to be free from defects in material and workmanship for a period of three (3) months from the date of installation or eighteen (18) months from the date of shipment when used under normal operating conditions and in accordance with the operating limitations and maintenance procedures given in the instruction manual and when not having been subjected to accident, alteration, misuse, abuse, freezing, scale coating, or poisoning ions.

Chemical solutions, standards or buffers carry an "out-of-box" warranty. Should they be unusable when first "out-of-box", contact IC CONTROLS immediately for replacement. To be considered for warranty, the product shall have an RA (Return Authorization) number issued by IC CONTROLS service department for identification and shall be shipped prepaid to IC CONTROLS at the above address.

In the event of failure within the warranty period, IC CONTROLS, or its authorized dealer will, at IC CONTROLS option, repair or replace the product non-conforming to the above warranty, or will refund the purchase price of the unit.

The warranty described above is exclusive and in lieu of all other warranties whether statutory, express or implied including, but not limited to, any implied warranty of merchantability or fitness for a particular purpose and all warranties arising from the course of dealing or usage of trade. The buyer's sole and exclusive remedy is for repair, or replacement of the non-conforming product or part thereof, or refund of the purchase price, but in no event shall IC CONTROLS (its contractors and suppliers of any tier) be liable to the buyer or any person for any special, indirect, incidental or consequential damages whether the claims are based in contract, in tort (including negligence) or otherwise with respect to or arising out of the product furnished hereunder.

Representations and warranties made by any person, including its authorized dealers, distributors, representatives, and employees of IC CONTROLS, which are inconsistent or in addition to the terms of this warranty shall not be binding upon IC CONTROLS unless in writing and signed by one of its officers.

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